Sky and TELESCOPE

In This Issue:

Astronomers Visit Mexico

Cassiopeia A

Lick 120-inch Photographs—IV

The Missing Messier Objects

Convention at San Jose

Northern and Southern Star Charts

★

Vol. XX, No. 4

OCTOBER, 1960

50 cents

★

Lick Observatory at dusk

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COMMENTS BY
VICTOR GOEDICKE

Director,
Ohio University Observatory

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Sky and TELESCOPE

CHARLES A. FEDERER, JR., *Editor*
JOSEPH ASHBROOK, *Technical Editor*

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Vol. XX, No. 4 OCTOBER, 1960

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Promoting American Education in Astronomy

FOR ASTRONOMY to continue flourishing in the United States, a growing supply of able younger men and women is needed for research and teaching. At present, however, the few universities with major astronomy departments train only a small number of future astronomers, while at other educational institutions much potential astronomical talent is diverted to unrelated professions.

Five years ago, the American Astronomical Society organized a committee on education in astronomy, which has thought deeply on this problem. As a practical step, the committee began an extensive visiting-professor program, with financial aid from the National Science Foundation. In the 1959-60 season, 12 leading astronomers visited 62 colleges.

During his stay of about two days, each visitor gave general addresses to the college student body, lectured on a semi-technical level to astronomy classes, and participated in seminars for advanced students. In addition, he advised the college administrators and faculty on starting an astronomy program or expanding the existing curriculum.

These tours have been so strikingly successful that in 1960-61 32 astronomers will participate, visiting about 100 institutions, including small liberal arts colleges, teachers' colleges, and junior colleges.

The committee on education, headed by J. M. Chamberlain of the American Museum-Hayden Planetarium, is planning a series of six color motion pictures on astronomy. The first one, The Realm of the Galaxies, was completed last February. For general showings and television use, each film will run 28½ minutes, and is designed at a level to interest high school seniors.

A third activity of the committee, also supported by the NSF, is its foreign visiting-professors program, which brings outstanding astronomers from other countries for stays of several months at active astronomy departments of American universities.

In the first half of 1960, four astronomers came: P. L. Bhatnagar of India was at Harvard for research on gas dynamics, and gave a course on stellar structure and evolution. Indiana University was host to W. Becker of Switzerland, an expert in the application of photoelectric photometry to Milky Way problems. The Polish specialist on stellar populations and variable stars, Miss W. Iwanowska, spent four months at Ohio State, while C. Schalén of Sweden worked on galactic structure with Case Institute of Technology astronomers. Each of these foreign scientists traveled to many other observatories, making personal contacts and interchanging ideas.

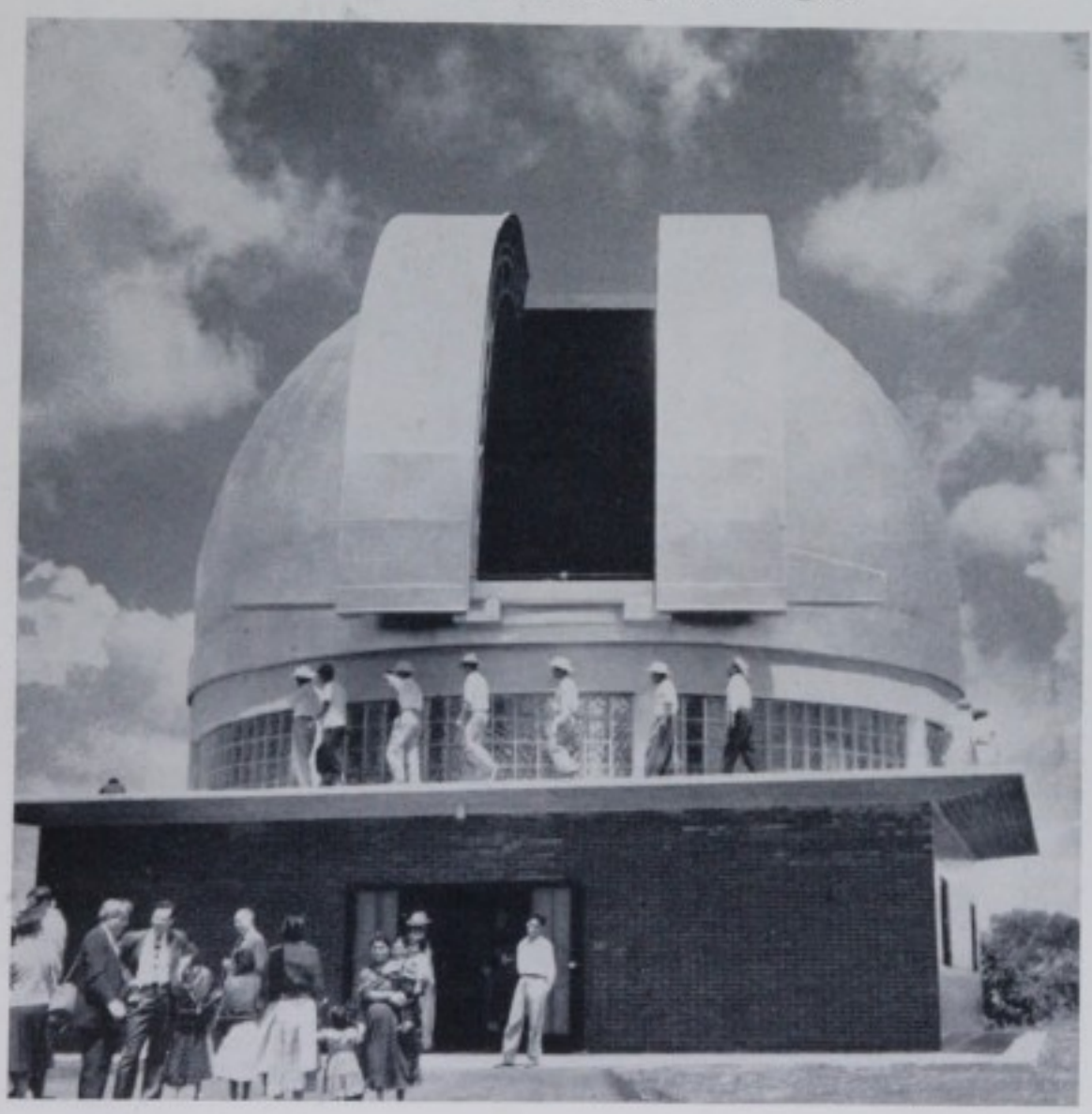
ASTRONOMERS VISIT MEXICO

Second largest metropolis in the Western Hemisphere, Mexico City with its nearly five million inhabitants is a bustling place, noteworthy for its many striking examples of modern architecture. Here the astronomers of North America convened in August. Sessions for the 80 technical papers were held in these buildings of the Ciudad Universitaria, the spacious campus of the Mexican National University, which has 58,000 students. On the left is the science tower, in which are located the astronomy department headquarters, and at the right is the science auditorium, with its great tiled mural here partly hidden by trees. Below are pictured the empty dome that awaits Tonantzintla Observatory's new 40-inch reflector and the revolving turret of the 27-inch Schmidt telescope (lower right).

FOR the first time in its history, the American Astronomical Society met in Mexico City, August 22-25. It was an appropriate gathering place, for Mexican astronomers have made significant contributions, especially since the founding of the Tonantzintla Observatory nearly two decades ago.

The first national observatory in Mexico was established at Chapultepec Castle (see page 188) in 1876. It was succeeded by the Tacubaya Observatory. With assistance from Harvard in the early 1940's, a large Schmidt telescope was set up at Tonantzintla for astrophysical research (SKY AND TELESCOPE, December, 1941, and April, 1942). There the present director, Dr. Guillermo Haro, our scientific host on this occasion, has developed an active scientific staff, for whose observing needs an f/15 40-inch Cassegrainian reflector is being built in Holland, to be delivered late this year.

The optics were made in California under the supervision of Don O. Hendrix, of Hale telescope fame. The f/5 40-inch primary has a 10-inch perforation, through which the light will be focused on a photoelectric photometer or a spectrograph, the former to be used about 60 per cent of the time. No Newtonian focus will be provided, but at the prime focus a nebular spectrograph may be used, or direct photographs taken. The observatory's main programs include photometry and spectroscopy of galaxies and clusters of galaxies, studies of T associations and T



Tauri stars, flare stars in the solar neighborhood, and Herbig-Haro objects wherever they may be found.

A highlight of the meeting was the Russell memorial lecture, given August 23rd by Martin Schwarzschild, of Princeton University Observatory, where he had been a colleague of the late Henry Norris Russell. Dr. Schwarzschild spoke on convection in stars, recalling that an uncle of his, Robert Emden, wrote the first basic book on stellar interiors, which was published half a century ago.

The Princeton astronomer then traced the development of theoretical models of stellar interiors, and reviewed our growing awareness of the complex processes that make the stars shine and permit the building up of the chemical elements.

An important related program is Project Stratoscope, which Dr. Schwarzschild has directed. He discussed the significance of its high-altitude pictures of the solar

Above left: Colorfully dressed citizens of Tonantzintla village await the arrival of 200 visiting astronomers, to tender them a civic reception. Native costumes and dances were featured in the program staged in the yard of the beautiful baroque church seen above right. The Cholula valley is famous for its hundreds of churches.

Right: The visitors gather on the steps of the headquarters of Tonantzintla Observatory, after their 80-mile trip from Mexico City.

These ancient pyramids at San Juan Teotihuacan, near Mexico City, discovered in 1904, are remains of the Toltec civilization that thrived about 2,000 years ago. At the left is the pyramid of the moon and at the right that of the sun. Many of the visiting astronomers climbed the 260-odd stone steps to the latter's summit to gain an impressive view of the countryside. The ruins are about 30 miles northeast of Mexico City.

Dominating Tonantzintla Observatory's western horizon are two famous volcanoes, Popocatepetl (pictured above) and Iztaccihuatl. Few of the visiting astronomers saw their summits, however, for after the observatory tour and lunch in the city of Puebla (230,000 inhabitants) it rained heavily.

granulations, which are believed to be convective cells located in the sun's photosphere.

Pictures of prominences on the sun were highlights of a lecture in Spanish given for the public by Donald H. Menzel, director of Harvard Observatory, on Friday evening, August 26th. Drs. Schwarzschild and Menzel are among those pictured on page 188 of this report.

C. A. F.

KEY TO GROUP PHOTOGRAPH

1, H; 2, P; 3, P; 4, V; 5, P; 6, V; 7, H; 8, H; 9, S; 10, T; 11, S; 12, F; 13, J; 14, C; 15, P; 16, R; 17, H; 18, C; 19, W; 20, I; 21, M; 22, S; 23, R; 24, M; 25, M; 26, M; 27, P; 28, W; 29, Z; 30, G; 31, B; 32, E; 33, D; 34, D; 35, M; 36, H; 37, M; 38, W; 39, B; 40, L; 41, L; 42, S; 43, H; 44, H; 45, B; 46, M; 47, B; 48, G; 49, B; 50, E.

51, M; 52, B; 53, C; 54, D; 55, D; 56, Z; 57, S; 58, M; 59, B; 60, H; 61, S; 62, M; 63, G; 64, G; 65, C; 66, H; 67, O; 68, G; 69, O; 70, M; 71, E; 72, H; 73, B; 74, H; 75, B; 76, V; 77, C; 78, C; 79, W; 80, M; 81, B; 82, S; 83, S; 84, G; 85, I; 86, I; 87, M; 88, I; 89, J; 90, I; 91, L; 92, L; 93, G; 94, D; 95, M; 96, E; 97, G; 98, S; 99, M; 100, J.

101, H; 102, C; 103, C; 104, C; 105, H; 106, J; 107, H; 108, R; 109, W; 110, F; 111, S; 112, T; 113, S; 114, O; 115, C; 116, O; 117, W; 118, R; 119, M; 120, C; 121, S; 122, E; 123, C; 124, M; 125, C; 126, E; 127, H; 128, H; 129, D; 130, E; 131, P; 132, P; 133, G; 134, S; 135, C; 136, S; 137, H; 138, S; 139, B; 140, M; 141, M; 142, S; 143, O; 144, R; 145, B; 146, W; 147, E; 148, E; 149, E; 150, E.

151, S; 152, S; 153, H; 154, F; 155, W; 156, S; 157, P; 158, S; 159, W; 160, P; 161, S; 162, C; 163, C; 164, C; 165, P; 166, A; 167, W; 168, R; 169, B; 170, M; 171, M; 172, G; 173, A; 174, M; 175, G; 176, H; 177, S; 178, W; 179, G; 180, H; 181, S; 182, E; 183, M; 184, D; 185, O; 186, P; 187, P; 188, H; 189, H; 190, M; 191, D; 192, J; 193, A; 194, K; 195, J; 196, J; 197, C; 198, O; 199, K; 200, L.

201, C; 202, P; 203, S; 204, S; 205, B; 206, D; 207, D; 208, C; 209, T; 210, S; 211, S; 212, S; 213, S; 214, S; 215, G; 216, D; 217, B; 218, P; 219, E; 220, S; 221, S; 222, W; 223, E; 224, H; 225, W; 226, E; 227, B; 228, B; 229, B; 230, O; 231, P; 232, M; 233, C; 234, I; 235, C; 236, T; 237, F; 238, S; 239, C.

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56, F. Zwicky, CIT; 29, Mrs. Zwicky.

KEY TO ABBREVIATIONS

AD, Astro-Dome; AF, Air Force Cambridge Research Labs.; CIT, California Institute of Technology; D, Dearborn Obs.; DD, David Dunlap Obs.; FC, Flower and Cook Obs.; H, Harvard Obs.; HAO, High Altitude Obs.; I, Indiana Univ.; KP, Kitt Peak National Obs.; L, Lockheed Aircraft Corp.; LA, Los Alamos Scientific Lab.; Li, Lick Obs.; Lo, Lowell Obs.; LS, Louisiana State Univ.; M, Mexico City; MWP, Mount Wilson and Palomar Obs.; N, U. S. Naval Obs.; NASA, National Aeronautics and Space Admin.; NBS, National Bureau of Standards; NRL, Naval Research Lab.; OAN, Observatorio Astronomico Nacional; P, Pasadena, Calif.; Pr, Princeton Univ. Obs.; S, Steward Obs.; SAO, Smithsonian Astrophysical Obs.; STL, Space Technology Labs.; UCLA, Univ. of California at Los Angeles; V, Vanderbilt Univ.; Vi, Villanova Univ.; VV, Van Vleck Obs.; W, Washburn Obs.

FACING PICTURE: Members of the American Astronomical Society and their guests on August 23, 1960, at the 106th meeting, Mexico City, Mexico. The identification key is on this page. Photograph by David Tellez.

At the society banquet, which was held in Chapultepec Castle (pictured below), the head table was set in one of the historic chambers, but most of the guests were served outdoors in the spacious patio. Photograph by David Telles.

Seen above on the far side of the head table are (left to right) T. Gurza; Mrs. Paris Pishmish Recillas, Mexican National Observatory; A. Barajas, National University of Mexico; D. H. Menzel, Harvard Observatory; Mrs. J. Torres-Bodet; G. M. Clemence, U. S. Naval Observatory; A. H. Joy, Mount Wilson and Palomar Observatories; Mrs. G. Haro; A. Arriaga, director of Chapultepec Castle; and Mrs. Charlotte Moore Sitterly, U. S. Bureau of Standards.

On the side near the camera are (left to right) G. Haro, Mexican National Observatory; J. A. Hynek, Dearborn Observatory; Mrs. T. Gurza; L. Spitzer, Jr., Princeton Observatory; J. Torres-Bodet, Mexican secretary of education; and Mrs. G. M. Clemence.

On August 22nd, a reception was given by our hosts (second and third from left), Guillermo Haro and Naber Carrillo, rector of the university. At the left is Alberto Barajas, university science co-ordinator, and at the right the editor of "Sky and Telescope."

The American Astronomical Society's president-elect, Lyman Spitzer, Jr., Princeton Observatory (at left), converses with fellow staff member Martin Schwarzschild (center), who gave the Russell lecture, and Aden B. Meinel, Kitt Peak National Observatory. Photographs by David Telles.

NEWS NOTES

SOUTH AMERICAN DOUBLE STAR EXPERT

Bernard H. Dawson, a Missouri-born astronomer who had been a staff member of La Plata Observatory in Argentina since 1912, died on June 18th at the age of 68.

Dr. Dawson was particularly known for his visual observations of southern double stars with the La Plata 17-inch refractor. He labeled the pairs he discovered with the Greek letter delta. The most important of them is δ31, a close and difficult binary in Sculptor, having an orbital period of only 4.56 years.

In addition, Dr. Dawson devoted much attention to variable stars, and was an independent discoverer of Nova Puppis in 1942. A prominent figure in both professional and amateur Argentine astronomy, he was three times acting director of La Plata Observatory.

GAMMA ANDROMEDAE AS A QUADRUPLE STAR

In small amateur telescopes, Gamma Andromedae appears as a beautiful pair, consisting of a 2.3-magnitude orange star with a 5.1-magnitude companion at a distance of 10 seconds of arc. About 120 years ago, the elder Otto Struve with the 15-inch refractor of Pulkovo Observatory discovered that the companion is itself a close pair of stars, B and C, of magnitudes 5.0 and 6.2, respectively. B and C form a visual binary system with an orbital period of 56 years. At the present time, the separation between them is 0.41 second of arc, increasing to 0.54 by 1970.

Three years ago, at Perkins Observatory in Ohio, Arne Slettebak used the 69-inch reflector to begin a series of spectrographic observations of the B-C pair. A doubling of the spectral lines, changing from night to night, revealed that one component — probably B — was a spectroscopic binary, so Gamma Andromedae is actually a system of four stars.

L. A. Maestre and J. A. Wright, also of Perkins, have now completed a study of the spectroscopic system from 28 spectrograms. They find that B consists of two similar stars, both of spectral type *B*9.5, revolving around their center of gravity in a period of 2.67 days. It is improbable that eclipses can occur, unless the spectroscopic components are abnormally large for their spectral class.

Another Perkins astronomer, P. C. Keenan, has redetermined the spectroscopic parallax of Gamma Andromedae A as 0.013 second of arc, corresponding to a distance of approximately 250 light-years — in good agreement with the distance from us of the B-C pair, which is known from its orbital characteristics. Thus Gamma Andromedae forms a true quadruple system, its four member stars moving through space together.

RECLASSIFICATION OF NORTHERN GALAXIES

Almost 30 years ago, the classic Shapley-Ames catalogue of galaxies brighter than 13th magnitude was published. While this is still the only complete survey of bright exterior systems over the entire sky, its present value is limited, since improved observational material has meanwhile become available, and the typing of galaxies has been refined.

Recently, Sidney van den Bergh, in a publication of the David Dunlap Observatory, has reclassified 935 of the Shapley-Ames galaxies, using the photographic atlas made with the 48-inch Schmidt telescope. These Palomar Sky Survey photographs cover the sky from the north celestial pole to declination −27°.

For each galaxy in the new catalogue are given the type, angular size, and total photographic magnitude. Also, when information was available, the Canadian astronomer included the spectral type, Yerkes concentration class (SKY AND TELESCOPE, January, 1959, page 129), and color.

Dr. van den Bergh assigned an intrinsic-luminosity grade, ranging from I (most luminous) to V (least luminous), to 411 spiral and irregular galaxies. Combining this information with the apparent brightnesses of these objects, their individual distances could be established. For others, the distances could be estimated on the basis of their observed velocities of recession (red shifts) as part of the expanding universe. The Hubble constant assumed for this work was an increase of 100 kilometers in recessional velocity for each million parsecs of distance, the most remote galaxies in the classification being some 200 million light-years away.

UNUSUAL ASTEROID

While examining photographs he had taken in South Africa in 1959, Cuno Hoffmeister of Sonneberg Observatory, East Germany, recently detected a fast-moving object in Sagittarius. The four photographs had been exposed with the Boyden Observatory's 10-inch telescope on June 5, 9, 10, and 11, 1959. On each picture the 13th-magnitude object appeared as a trail, indicating motion of about a degree per day toward the west.

Calculations made by J. Schubart, also of Sonneberg, indicate that the newly found body is probably a minor planet, accidentally recorded as it passed about 30 million miles from the earth. Although the observations are too limited to determine the path accurately, Hoffmeister's object appears to be moving in a highly elliptical orbit (eccentricity 0.67), inclined only about eight degrees to the ecliptic. When nearest the sun, it is just within the orbit of Venus, and at its farthest from the sun it is almost twice as distant as Mars.

IN THE CURRENT JOURNALS

STELLAR ASTRONOMY FROM A SPACE VEHICLE, by Arthur D. Code, *Astronomical Journal*, June, 1960. "The opportunity to carry out astrophysical investigations throughout the entire electromagnetic spectrum, through the use of space vehicles, cannot fail to have a tremendous impact on the future course of stellar astronomy. The possibility of realizing the full resolving power of astronomical telescopes and conducting observations freed of the bright sky background contributed by scattered light and permanent aurorae is also of great significance."

THE ZODIACAL LIGHT, by D. E. Blackwell, *Scientific American*, July, 1960. ". . . We can already say that the electron density in the vicinity of the earth is far lower than has hitherto been supposed, and that electron scattering can make only a small contribution to the zodiacal light. It seems, therefore, that Cassini is right after all; the zodiacal light is due to dust scattering."

294,000 METEORS

Counts of meteors made by hundreds of observers in many parts of the world during the years 1901 to 1958 have been collected and analyzed by C. P. Olivier, former director of Flower and Cook Observatory. From this material, totaling about 294,000 meteors, he has compiled an extensive table giving the average rate for each hour on every night of the year.

All of the original counts were visual, and hence depended upon the skill of observers and whether visibility was impaired by moonlight or haze. Therefore, correction factors were applied to provide the number of meteors per hour that an experienced observer would have seen under ideal conditions. For this reason, the rates as catalogued by Dr. Olivier are about 25 per cent higher than ordinarily recorded.

Dr. Olivier's catalogue has been published as Vol. 4, No. 1, of *Smithsonian Contributions to Astrophysics*. It is available at 15 cents per copy from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

BUILDING PLANS AT MICHIGAN

A new physics-astronomy building at the University of Michigan is expected to be completed by the fall of 1962. It will provide about 21,000 square feet of space for the department of astronomy, including some 40 staff and graduate student offices, laboratories, seminar rooms, and darkrooms. The astronomy and physics libraries will be combined.

The present observatory will continue to house the 37-inch reflector, meridian circle, and 12-inch refractor.

Fig. 1. Radio source Cassiopeia A is located in a seemingly blank area centered 2¾ inches from the left and 1¾ inches from the bottom in this Palomar Schmidt photograph. Several gaseous nebulae in this region were found to be weaker radio sources by C. R. Lynds, National Radio Astronomy Observatory. These include the large wreathlike nebulosity to the right of center, and NGC 7538, the small bright patch at upper right; also, two inches below top center, the bright nebula NGC 7635. Near the last is the open cluster M52.

Cassiopeia A

OTTO STRUVE

*National Radio Astronomy Observatory**

ONE of the most remarkable features of the Milky Way is located in the constellation Cassiopeia, about six degrees west of the star Beta, where a visual observer, even with a large telescope, will see nothing unusual (Fig. 1). Yet it is from this region of our galaxy that we observe very powerful radio emission at meter wave lengths, rivaling that from the sun, despite the fact that the Cassiopeia source is about 11,000 light-years distant, while the sun is only eight light-minutes away.

This discrete radio source was, I believe, first clearly shown on Grote Reber's 1944 radio map of the sky (Fig. 2), which was based on observations made at a wave length of 1.9 meters with his homemade radio telescope in Wheaton, Illinois. Known as Cassiopeia A, it was rediscovered in 1948 by M. Ryle and F. G. Smith at Cambridge, England, and it has since been assiduously observed by many radio astronomers.†

In spite of its great intensity at radio frequencies, all attempts to identify this source with an astronomical object on photographs failed until 1951, when Smith obtained an exact determination of its co-ordinates from observations with a large radio interferometer:

R.A.: $23^h\ 21^m\ 12^s.0 \pm 1^s$ (1950.0)
Dec.: $+58°\ 32'.1 \pm 0'.7$ (1950.0).

With the help of this position, W. Baade and R. Minkowski searched direct photographs taken with the 200-inch Hale telescope, and found an area about four minutes of arc across, containing some 200 small nebulous fragments and condensations (Fig. 3). The center of this area lies at $23^h\ 21^m\ 09^s.4$, $+58°\ 32'\ 27''$, in close agreement with the center of the radio source. Moreover, Smith's interferometer measurements, and 125-megacycle work by R. Hanbury Brown, R. C. Jennison, and M. K. Das Gupta, at Jodrell Bank, show that Cassiopeia A is not a point source, but seems to be a round spot whose diameter is about five minutes of arc.

On the Palomar plates, the nebulosities are of two distinct types. The first are sharp, broken bits that can be photographed only in red light. These show no measurable proper motions, and have small radial velocities. Their spectra display emission lines of hydrogen, along with forbidden lines of neutral oxygen and singly ionized nitrogen, as seen in Fig. 4.

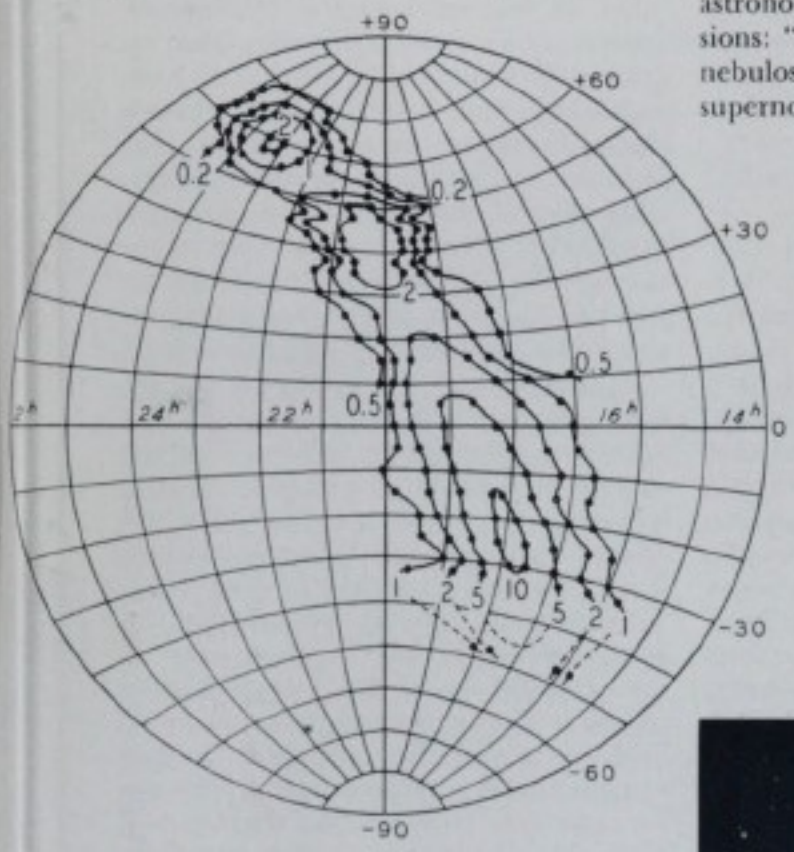
The second variety consists of other, more diffuse-looking nebulosities that can be photographed in both blue and red light. Their spectra (Fig. 5) show no hydrogen, but very strong forbidden emission lines of neutral and doubly ionized oxygen. It is likely that the oxygen atoms

*Operated by the Associated Universities, Inc., under contract with the National Science Foundation.

†In 1955, the International Astronomical Union adopted a new form of designation for radio sources. In this system, Cassiopeia A is called 23N5A: 23 stands for the hour of right ascension, N for the northern hemisphere, 5 for 50 to 60 degrees of declination, and A for the order of discovery in that area.

are excited to shine, not by radiation falling on them, but by collisions with interstellar atoms.

The blue-red nebulosities are remarkable for their enormous radial velocities, ranging between about 6,000 kilometers per second of recession and 4,000 of approach. Fig. 6 was drawn by Minkowski



to show how the observed radial velocities depend on angular distance from the center of the area. The plot at the left for the fast-moving, blue-red wisps indicates that they form a group expanding outward from the center at a rate of about 7,440 kilometers per second. The second plot, for the slow-moving red fragments, shows that they do not participate in the expansion.

The rapidly moving wisps also have large proper motions directed outward from the center. According to Minkowski, the proper motions amount to 0.46 second of arc per year, at a distance of 118 seconds from the center. If the expansion has been proceeding at a uniform rate, it therefore began about $118/0.46 = 256$ years ago — around A.D. 1700.

From the same data, the Palomar astronomer estimated the distance of Cassiopeia A, on the assumption that 7,440 kilometers per second is also the expansion velocity at right angles to the line of sight. If this velocity produces the angular shift of 0.46 second per year, then the distance is $7{,}440/(4.74 \times 0.46) =$ 3,400 parsecs, or about 11,000 light-years.

From the spectra of the fast-moving nebular fragments, Minkowski and L. H. Aller have estimated that they contain some 1,000 to 10,000 hydrogen atoms per cubic centimeter. Their average density is thus of the order of 10^{-20} gram per cubic centimeter. Since the individual wisps are about one or two seconds of arc in diameter, they have volumes of about 4×10^{50} cubic centimeters. Each one would contain $4 \times 10^{50} \times 10^{-20} = 4 \times 10^{30}$ grams of matter. All 200 fragments would come to about 10^{33} grams — half the sun's mass. But only a fraction of the total shell is visible, and hence the entire exploded material may well amount to one or two solar masses.

At the 1958 Paris symposium on radio astronomy, Minkowski told of his conclusions: "There is no longer doubt that the nebulosity is the remnant of a type II supernova. This is the only type of object

Fig. 2. Three discrete radio sources are recognizable in Grote Reber's historic sky map of 1944. Cassiopeia A is at the upper left, Sagittarius A at lower right, with Cygnus A between them, all superimposed on the general radio emission from the Milky Way. Adapted from the "Astrophysical Journal."

for which velocities of expansion of the order 5000 km/second have been reported; a value of 7500 km/second is well within the range of possible interpretations. Moreover, no other type of nova or supernova is known to have an ejected mass of the order of 1 solar mass. An ejected mass of this order seems acceptable for the type II supernovae, which as members of Baade's Population I may be very massive stars. At a distance of 3400 parsecs and with an interstellar absorption of about 6 magnitudes over the center of the nebulosity, the expected apparent brightness of a supernova of type II is about +5 magnitudes, too faint to expect discovery of the supernova [when it was at maximum light about A.D. 1700]."

The last conclusion can be easily verified. According to C. W. Allen's 1955 compilation, the absolute magnitude of a type-II supernova at maximum light is −12.9. Such a star viewed at 3,400 parsecs would be 340 times more distant than a similar one at the standard distance of 10 parsecs for which absolute magnitude is calculated. Since the brightness of a point source varies inversely as the square

Fig. 3. A Hale telescope picture in red light shows the Cassiopeia A region to be dotted with many tiny shreds of nebulosity, some sharp and angular, others with diffuse edges. Mount Wilson and Palomar Observatories photograph.

of the distance, the remoter supernova would be 1/340² as bright, or about 12.5 magnitudes fainter than the nearby one.

If there were no interstellar absorption, the former would have appeared as a star of visual magnitude $-12.9 + 12.5 = -0.4$. With an absorption of six magnitudes, its apparent magnitude would have been $-0.4 + 6.0 = +5.6$. This is only slightly above the limit of naked-eye vision – a temporary star that faint would almost certainly have been overlooked 2½ centuries ago, when astronomers were few and star charts incomplete.

The hypothesis that Cassiopeia A is the remnant of an old supernova was strongly advocated by I. S. Shklovsky, long before Minkowski and Baade reached the same conclusion. However, in his 1956 book on radio astronomy (now available as *Cosmic Radio Waves* in an English translation by R. B. Rodman and C. M. Varsavsky, and published by the Harvard University Press), Shklovsky depended on an earlier and now obsolete estimate of the distance – 500 parsecs. Furthermore, he supposed that the nebulosity was formed between 700 and 2,000 years ago, by the outburst of a supernova that attained an apparent magnitude of perhaps −3.5.

These inferences led Shklovsky to identify Cassiopeia A with "an unusual star" recorded in ancient Chinese chronicles as appearing in Cassiopeia in March of A.D. 369. The object became invisible in August of the same year. According to K. Lundmark, this was very probably a genuine nova or supernova that became as bright as magnitude −3. However, the Chinese astronomer Hsi Tse-tsung questions the identification of this star with the radio source, and Shklovsky has now abandoned it. In his latest paper, in the *Russian Astronomical Journal* for January, 1960, he has accepted Minkowski's age determination.

Nevertheless, the Soviet astronomer's extensive historical investigations have led to an important result. He has found that, during the past 2,000 years, six or seven supernovae have been recorded in the Milky Way system. Allowing for the fact that only the nearer ones would have been recognized, he deduced that supernovae are appearing in our galaxy at an average rate of one in 30 to 60 years. Apparently, Milky Way supernovae occur much more frequently than F. Zwicky's figure of once per 200 or 300 years, deduced from observations of other galaxies, most of which are smaller than ours.

As in other instances – the planetary nebulae, the supernova shell of the Crab nebula, and the Veil nebula in Cygnus – the expanding gases of Cassiopeia A encounter the approximately stationary material of interstellar space. In G. Westerhout's opinion, the density of this material in the neighborhood of Cassiopeia A is about 0.2 hydrogen atom per cubic centimeter. Therefore, if we assume that the expanding shell has a mass equal to the sun's, its velocity would have been reduced by only 10 per cent by the time it reached its present two-parsec radius.

However, Fig. 6 indicates the expansion is not quite symmetrical: The approaching side of the shell has been decelerated more than the receding one. Minkowski therefore suggests that the nearer side has encountered interstellar material of somewhat greater than average density, say 0.8 hydrogen atom per cubic centimeter.

We still have no very satisfactory interpretation of the nearly stationary red condensations, which are fewer in number but 50 times more massive than the blue-red ones. Perhaps, as Minkowski proposes, they were originally fast-moving fragments that were arrested by collisions with small dense pockets of matter, containing 10^5 or 10^6 hydrogen atoms per cubic centimeter. One difficulty is that, though we have long known the interstellar medium to be nonuniform, there have been no previous indications of "graininess" to the degree required by Minkowski's hypothesis.

Let us now turn to the problem of Cassiopeia A's radio emission. Observations of the Crab nebula (Taurus A) have established that it emits light of two kinds. There are bright filaments that have an emission-line spectrum resembling that of ordinary gaseous nebulae. In addition, there is an amorphous nebulosity giving off highly polarized light by a process known as synchrotron radiation, which also produces the radio emission.

In Cassiopeia A, we observe at optical wave lengths a bright-line spectrum, due to excited atoms in the nebula. There is no optical synchrotron radiation. But it is reasonable to believe, as Shklovsky and others have shown, that the radio emission is in fact caused by the synchrotron effect.

Terrestrially, this type of radiation has been observed in large nuclear accelerators. It is due to very fast – so-called relativistic – electrons moving in a magnetic field. A free electron traveling along a straight line at a constant speed produces no radiation. However, the electron will emit radiation if it is accelerated or decelerated, as when it traverses a hyperbolic path around a proton or other heavy particle.

When a free electron moves in a magnetic field, with a relatively slow velocity along the direction of the field, it experiences a disturbance that causes it to describe a circular path, in addition to its original rectilinear motion, so that the orbit becomes a helix. The changing direction is actually an acceleration of the

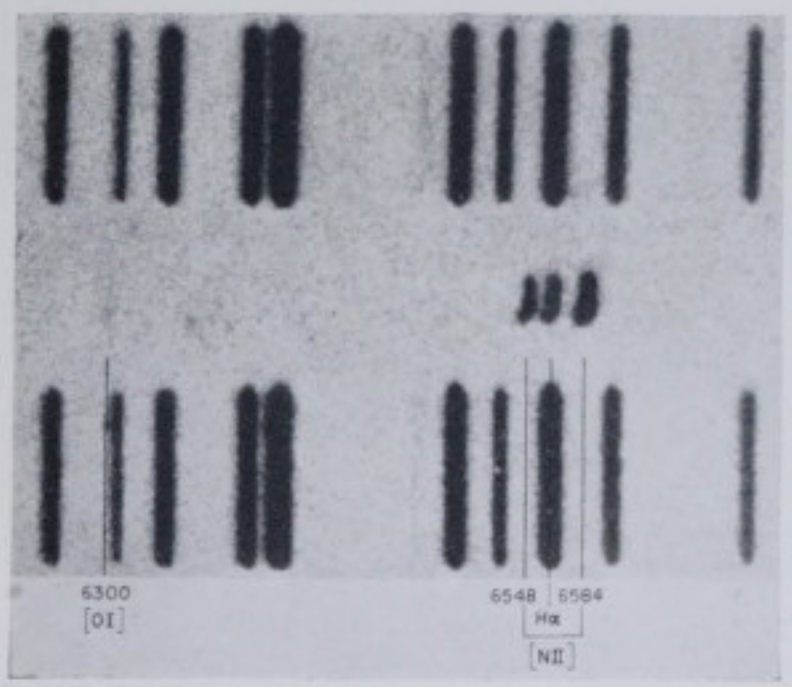


Fig. 4. Sharp red nebulosities in Cassiopeia A show hydrogen and nitrogen emission as well as oxygen, as this Baade-Minkowski spectrogram indicates. Spectra courtesy "Astrophysical Journal."

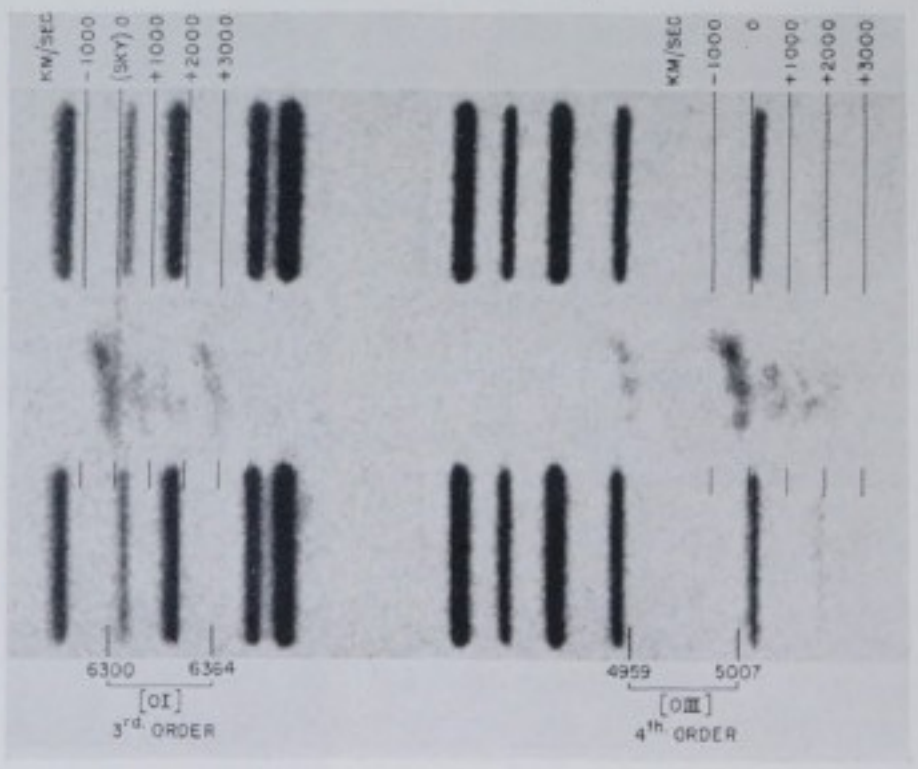


Fig. 5. A diffuse blue-red nebulosity in the field has a spectrum (middle strip) containing only oxygen lines, whose compound structure indicates internal motions. W. Baade and R. Minkowski used the 200-inch Hale telescope for this observation.

electron, just as the earth is accelerated in its orbit around the sun.

In the case of the electron, radiation is produced, and its frequency can be computed. This frequency depends only on the magnetic field strength (provided the electron has a low velocity), so a discrete emission line is formed.

Magnetic fields in interstellar space are believed to be very weak. Field strengths of 10^{-5} gauss have been suggested from polarization measurements of starlight. For that value, the electron's radiation frequency would be 30 cycles per second, corresponding to a wave length of 10,000 kilometers! This would not be observable.

An electron traveling at nearly the velocity of light through a magnetic field radiates in an entirely different manner. The electron still has a helical trajectory, but its radiation is confined to an extremely narrow cone whose axis is tangent to the circular path. Hence the emitted radiation sweeps across the observer at very short intervals every time the electron is in the appropriate location on its path (Fig. 7). These radiation flashes cannot be observed separately; we see the integrated effect of many of them, which can be interpreted as a combination of all the overtones of the original frequencies.

Physical theory thus predicts that instead of a line spectrum the observer will see a continuous spectrum. In the case of an electron with an energy of 10^9 electron volts in a 10^{-5}-gauss field, the continuum would be most intense at a frequency of 120 megacycles per second, or a wave length of 2.5 meters. Such radio emissions can be easily observed with existing radio telescopes.

But while the magnetic field inside the small region of the Milky Way occupied by Cassiopeia A may be approximately uniform, the electrons in it have a wide range of velocities and energies. The total observed flux from Cassiopeia A is the sum of the contributions from all the electrons. This flux is proportional to the volume of the emitting cloud, to a power of the frequency at which observations are made, and to a power of the magnetic field strength.

Shklovsky has assumed that the strength of the magnetic field decreases as the nebula expands. At the same time, the energies of all its electrons must decrease. Thus he deduces that the radiation flux is gradually diminishing, at a rate of two per cent per year if the nebula is 300 years old.

Measuring this change in flux directly is difficult, but J. W. Findlay is now attempting to do so with a large horn antenna at the National Radio Astronomy Observatory. Meanwhile, Shklovsky has suggested it would be relatively easy to detect the decay of Cassiopeia A by measuring the ratio R of the flux from the constant source Cygnus A (a pair of colliding galaxies) to the flux of the former source. Only four reliable determinations of this ratio were available when the Soviet astronomer wrote his recent paper:

Observer	*Megacycles*	*Year*	*R*
J. P. Hagen	1,420	1954	0.550
G. Westerhout	1,390	1956	0.613
G. B. Field	1,360-1,440	1957	0.629
P. G. Mezger	1,419	1958	0.613

The results in the last column are somewhat discordant, probably because different frequencies and different instruments were used. At NRAO, D. S. Heeschen has been making 1,420-megacycle observations of the flux ratio during the last 1½ years with the 85-foot Tatel radio telescope. His preliminary results, tentative as they are, indicate a change of about 0.5 per cent annually. His values of R tend to be somewhat larger than those listed above. It is probable, therefore, that the flux of Cassiopeia A is actually diminishing, but at a slower rate than Shklovsky's two per cent. Whatever the final result may be, it is certain to throw new light on the mechanism of cosmic synchrotron radiation.

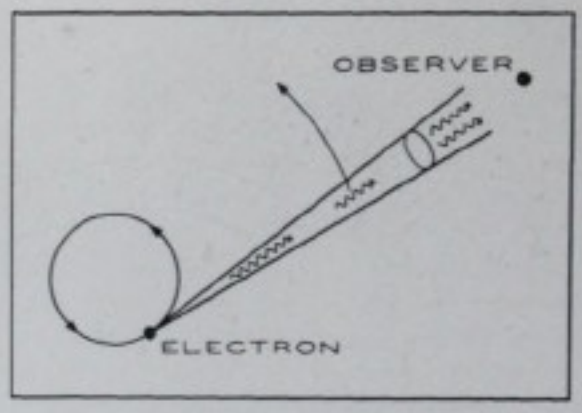


Fig. 7. A fast electron spiraling through a magnetic field emits synchrotron radiation in a narrow cone, as explained in the text.

The question arises whether the assumptions that underlie Shklovsky's theory are satisfied. These are, first, that the radio emission is actually synchrotron radiation and does not come, for example, from plasma oscillation; second, that the nebula is expanding with the velocity found from optical measurements; third, that the magnetic field intensity decreases in the manner specified; and fourth, that the relativistic (high-speed) electrons were injected into the nebula only during the early stages of the outburst, and that their energy decreases proportionately with time as the shell expands.

Shklovsky believes the first three premises are probably correct. The fourth is not so certain. In the case of the Crab nebula, J. H. Oort and his associates have found that new relativistic electrons are probably being fed into the shell even at the present time — 900 years after the outburst. Possibly, then, the flux decline of Cassiopeia A is less rapid than the Soviet scientist predicted.

We do not yet know how to compute the radiation flux during the early stages of the expansion of the debris from a supernova outburst. Shklovsky's formulas lose their validity if the shell's age is less than a century or so. In a general way, it is reasonable to expect that the synchrotron radiation increases at first, attaining its maximum much later than the time of greatest visual brightness. Afterward, there is a decline in accordance with Shklovsky's formula, or some modification of it.

Further, no one knows how soon after a supernova explosion the radio emission may become observable. It is possible that even ordinary novae, located not too far from the sun, may become radio sources a few decades after they explode.

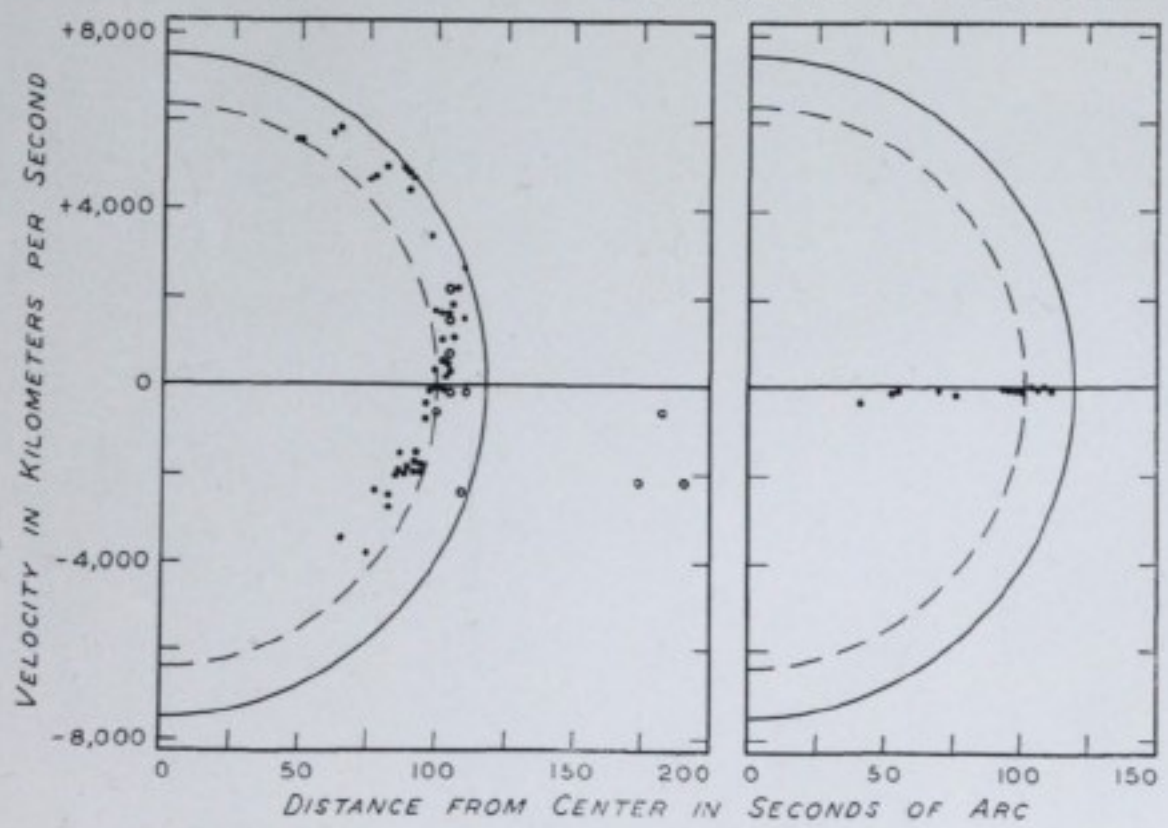


Fig. 6. R. Minkowski plotted radial-velocity measurements for Cassiopeia A's blue-red nebulosities (left) and red ones (right) to show the expansion in the first case. From "Paris Symposium on Radio Astronomy," R. N. Bracewell.

Part of the Corona Borealis cluster of galaxies, as recorded with Lick Observatory's new 120-inch telescope. A 2¼-times enlargement has been made from N. U. Mayall's negative, a 30-minute exposure in blue light on June 26, 1960. This nest of very faint galaxies, some 400 of them within a full-moon area, is so distant that their spectra show a red shift of 22,000 kilometers per second. All photographs are courtesy Lick Observatory.

Lick 120-inch Photographs — IV

The famous Ring nebula, M57 in Lyra, is a luminous bubble of tenuous gas, excited to shine by its very hot, blue central star. Because this five-minute exposure with the 120-inch reflector was made in red light, the central star looks faint, while an otherwise inconspicuous star, seemingly within the ring, is accentuated. Dr. Mayall took this picture on June 27th this year, enlarged here 9.3 times.

FACING PICTURE: The intricate beauty of great cosmic nebulosities and dark obscuring matter in the Trifid nebula in Sagittarius is revealed in this red-light picture. It is a half-hour exposure on 103a-E(2) emulsion with an RG1 filter, taken by Dr. Mayall on June 27, 1960. The enlargement scale is 4.4 seconds of arc per millimeter, and south is upward. The Trifid is M20, located very near the winter solstice point of the sky.

The Missing Messier Objects

OWEN GINGERICH, *Harvard College Observatory*

IN the famous catalogue of 103 nebulae and clusters compiled by Charles Messier are several enigmas that baffle many present-day observers. At the positions given for the clusters M47 and M48, and for the nebulae M91 and M102, no objects are found. From time to time identifications have been suggested, but only recently have some of these discrepancies been fully explained.

The frequently overlooked solution to the mystery of the last object was actually published in 1782, only a year following the last installment of the catalogue: M102 is identical to M101, the duplication occurring because of an error in reading a star chart. Reasons for similar errors can now be found enabling us, in my opinion, to identify M47 as NGC 2422, M48 as NGC 2548, and M91 as a duplication of M58 (NGC 4579).

Messier's catalogue consists of an original list of 45 objects, published in the *Mémoires* of the Académie des Sciences in Paris for 1771, and two supplements in the French almanac *Connaissance des Temps* for 1783 and for 1784 (published in 1780 and 1781). Although Messier had observed the first nebula of the list in 1758, positions of most of the original 45 objects were determined during the summer of 1764.

Before presenting his memoir to the Paris academy, Messier checked many previously reported nebulae in order to make his list as complete as possible. The chief lists that had been published before 1770 were a brief catalogue of five objects by Edmond Halley; a longer tabulation by William Derham of Winchester, England, which was primarily gleaned from Hevelius' star catalogue (*Prodromus Astronomiae*), and available to Messier in a French translation published by P. de Maupertuis in the Paris *Mémoires* for 1734; and the list of southern nebulae by N. de Lacaille in the *Mémoires* for 1755 (SKY AND TELESCOPE, February, 1960, page 207).

Messier located some of the objects in these compilations, but not all. He realized that many of them were not nebulous when examined with a telescope, but were mere asterisms. One of these, near the stars 74 and 75 Ursae Majoris, he listed as No. 40. The description in the *Connaissance des Temps* reads: "Two faint stars, very near one another . . . they can scarcely be distinguished with an ordinary refractor of six feet [in length]. . . . It was in searching for the nebula . . . which Messier could not see, that he has observed these two stars." Thus M40 is not a missing object, although it is frequently omitted from contemporary catalogues.

The first two real puzzlers in the list, M47 and M48, were recorded on February 19, 1771, along with the clusters M46 and M49. These objects begin the first supplement to Messier's original list. The descriptions of M46-48, translated from this supplement in the *Connaissance des Temps* for 1783, are:

46. $7^h\ 31^m\ 11^s$, $-14°\ 19'\ 07''$
Cluster of very faint stars, between the head of the Great Dog and the two hind feet of the Unicorn, located by comparing this cluster with the 6th-magnitude star 2 Navis (according to Flamsteed); these stars can be seen only with a good refractor; the cluster contains a little nebulosity.

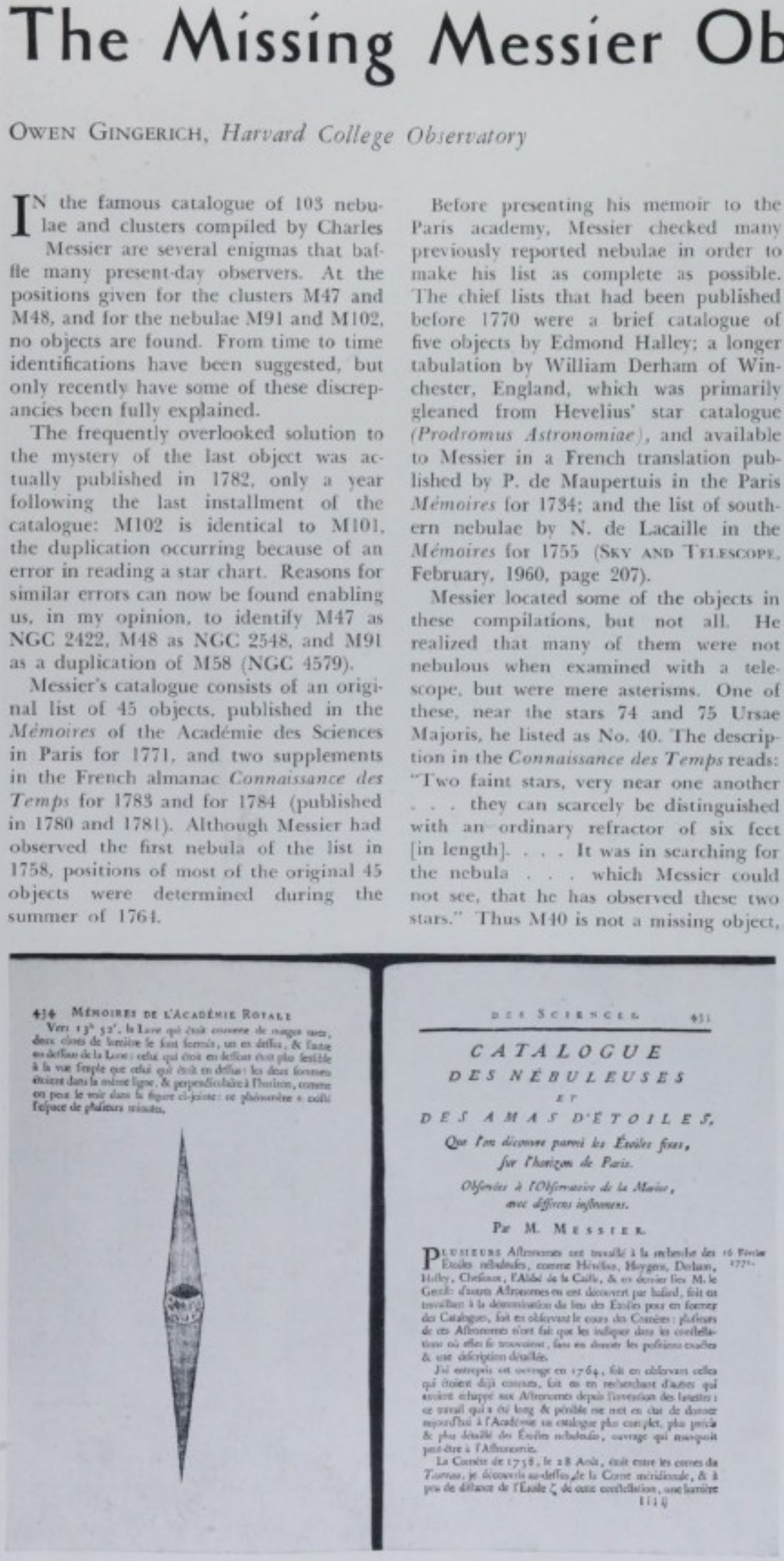
47. $7^h\ 44^m\ 16^s$, $-14°\ 50'\ 08''$
Cluster of stars a short distance from the preceding; the stars are brighter; the middle of the cluster was compared with the same star, 2 Navis. The cluster contains no nebulosity.

48. $8^h\ 02^m\ 24^s$, $-1°\ 16'\ 42''$
Cluster of very faint stars, without nebulosity; this cluster is a short distance from the three stars that form the beginning of the Unicorn's tail.

The position given for M47 falls in a comparatively empty part of a rich Milky Way region. By successive copying, this spurious position received the number NGC 2478, although no astronomer since Messier was able to confirm the observation. There is, however, a fine cluster in this region, brighter than M46 and so close to it that Messier could hardly have overlooked it. This cluster, NGC 2422, was identified as M47 by Oswald Thomas in his *Astronomie* (1934).

More explicit reasons for this identification were given independently last year by T. F. Morris, a member of the Messier Club of the Royal Astronomical Society of Canada's Montreal Centre. Dr. Morris suggested that an error in signs in the differences between M47 and the comparison star could account for the position.

Messier determined the declination of a nebula or cluster by measuring the difference between the object and a comparison star of known declination. The right ascension could be found by recording the times at which the object



414 MÉMOIRES DE L'ACADÉMIE ROYALE

Vers $13^h\ 52'$, la Lune qui était couverte de nuages vers, deux clous de lumière le font formés, un en dessus, & l'autre en dessous de la Lune: celui qui était en dessus était plus sensible à la vue simple que celui qui était en dessus: les deux sommets étaient dans la même ligne, & perpendiculaire à l'horizon, comme on peut le voir dans la figure ci-jointe: ce phénomène a duré l'espace de plusieurs minutes.

DES SCIENCES. 431

CATALOGUE
DES NÉBULEUSES
ET
DES AMAS D'ÉTOILES,
Que l'on découvre parmi les Étoiles fixes,
sur l'horizon de Paris.
Observées à l'Observatoire de la Marine,
avec différens instrumens.

PAR M. MESSIER.

PLUSIEURS Astronomes ont travaillé à la recherche des Étoiles nébuleuses, comme Hévélius, Huygens, Derham, Halley, Cheseaux, l'Abbé de la Caille, & en dernier lieu M. le Gentil: d'autres Astronomes en ont découvert par hasard, soit en travaillant à la détermination du lieu des Étoiles pour en former des Catalogues, soit en observant le cours des Comètes: plusieurs de ces Astronomes n'ont fait que les indiquer dans les constellations où elles se trouvaient, sans en donner les positions exactes & une description détaillée. 16 Février 1771.

J'ai entrepris cet ouvrage en 1764, soit en observant celles qui étaient déjà connues, soit en en recherchant d'autres qui avaient échappé aux Astronomes depuis l'invention des lunettes: ce travail qui a été long & pénible me met en état de donner aujourd'hui à l'Académie un catalogue plus complet, plus précis & plus détaillé des Étoiles nébuleuses, ouvrage qui manquait peut-être à l'Astronomie.

La Comète de 1758, le 28 Août, était entre les cornes du *Taureau*, je découvris au-dessus de la Corne méridionale, & à peu de distance de l'Étoile ζ de cette constellation, une lumière

Iiij

The first part of Charles Messier's catalogue of nebulae and clusters was printed in the memoirs of the French Royal Academy of Sciences for 1771.

M46 (right) and NGC 2422 (lower left), photographed by the Palomar 48-inch Schmidt camera. South is at the top in this reproduction, corresponding to the view in an inverting telescope. The width of the picture is slightly over two degrees. Both of these objects are open clusters; M46 is classed as fairly rich, the other as loose. According to the author, M47 is NGC 2422, the catalogue position given by Messier being in error (see chart below).

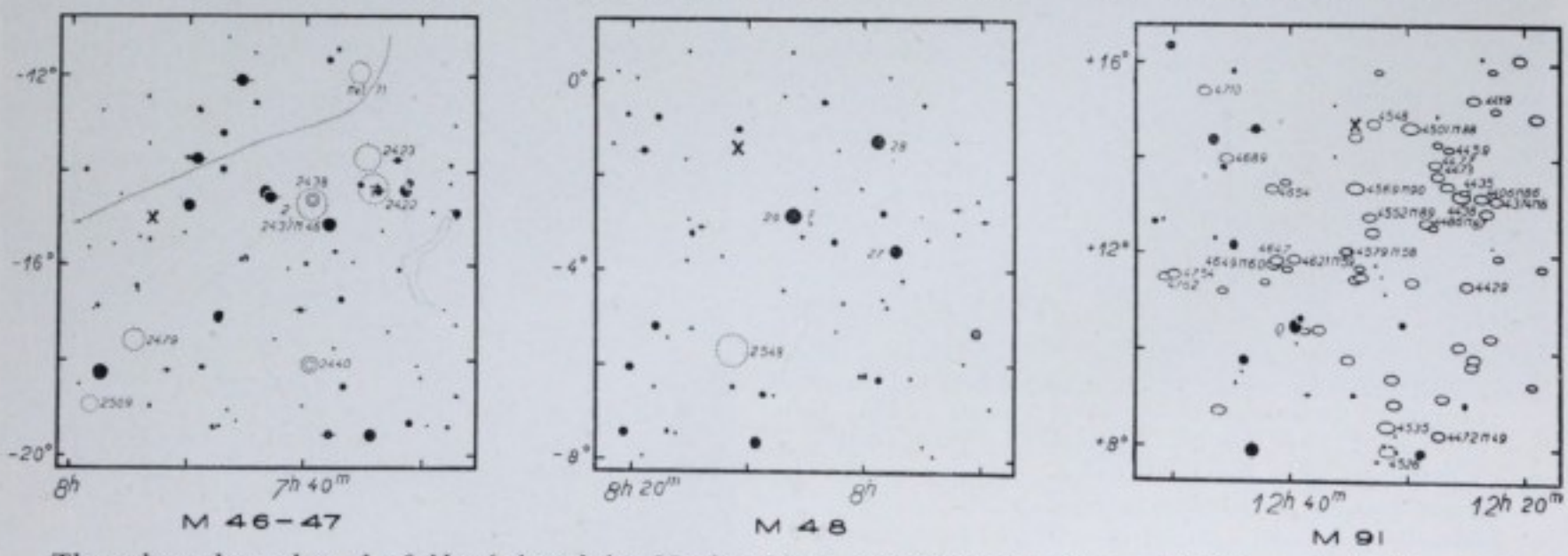
and the star drifted across a central wire in his telescope's field; the time interval gives the difference in right ascension. The differences between Messier's 1770 position for M47 and his stated comparison star, 2 Navis (now 2 Puppis), if applied with opposite signs, lead to NGC 2422. Clearly, Messier made a mistake in computation!

Although the circumstances of M48 are not as obvious, only one cluster of the size and brightness likely to be recorded by Messier is found in the region near "the three stars that form the beginning of the Unicorn's tail" (Zeta, 27, and 28 Monocerotis). Dr. Morris has pointed out that this cluster, NGC 2548, has the same right ascension as the position given for M48. (Allowance must, of course, be made for precession in comparing Messier's figures with modern positions.)

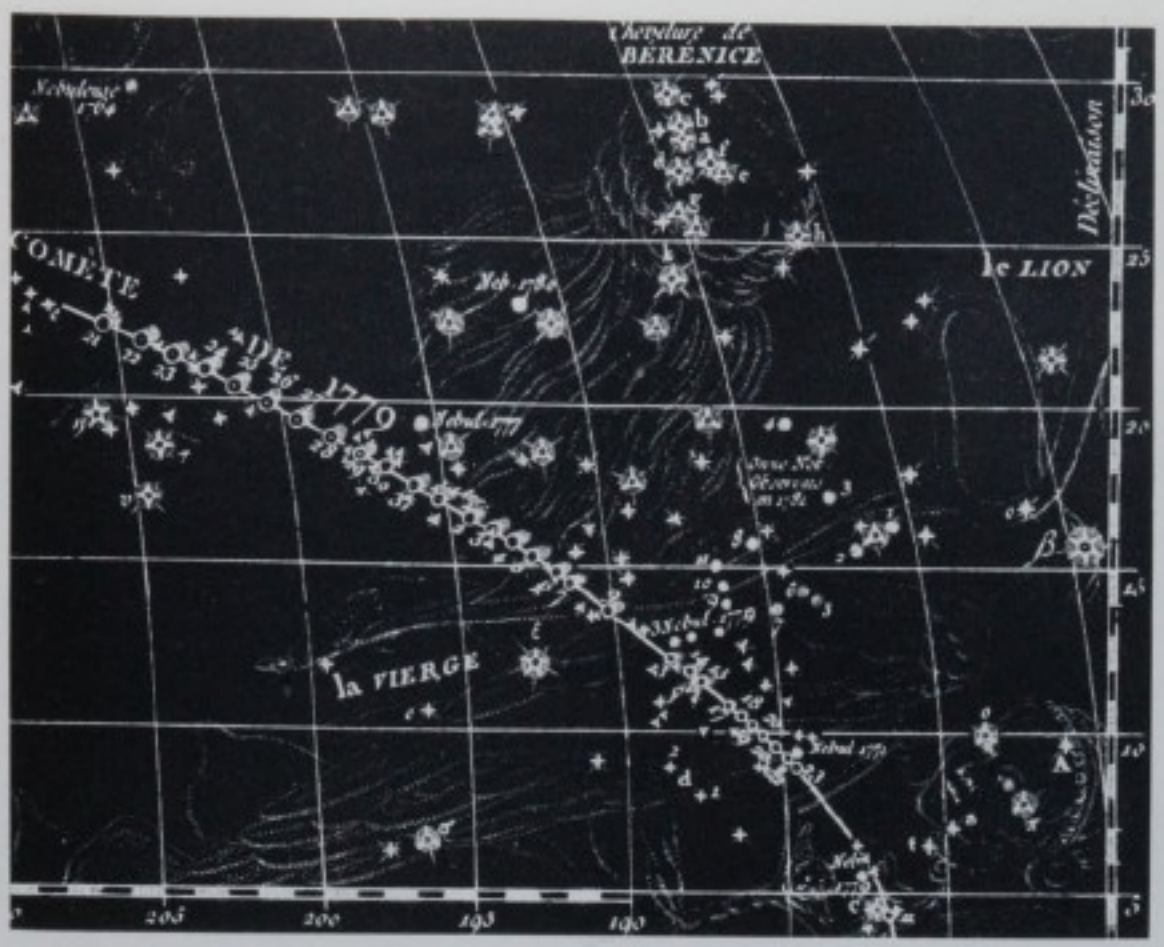
The declinations disagree by about five degrees. Since no conspicuous star is located 2½ degrees away in declination, we cannot account for this position by another error in sign. It seems unlikely that the comparison star was misidentified, since the right ascension is probably correct. Messier did not publish the name of the star used, and his original records are apparently no longer extant. I have examined all of his observing books preserved at the Paris Observatory, but none are included from this period.

Thus, a careful survey of the region described by Messier leads to the conclusion that NGC 2548 is the cluster the French observer intended as his 48th object, for lack of any other cluster nearby that fits the description.

The next mystery in the list is M91,



These three charts show the fields of the missing Messier objects. The catalogue position of M47 is marked with an X in the first map, as are those of M48 and M91 in the second and third. Adapted from the Skalnate Pleso atlas.



This section from one of Messier's comet charts in the memoirs of the Paris academy shows the nebulae he discovered in the Coma-Virgo region.

a nebula first recorded by Messier in the second supplement to his catalogue, published in 1781. M91 was the last of a group of eight nebulae observed on the night of March 18, 1781, in the confusingly rich Coma-Virgo region. In the same area two years earlier, Messier had measured the positions of M58, M59, and M60. His attention was recalled to this remarkable part of the sky by his colleague, Pierre Méchain, who was the first to appreciate the abundance of nebulae there. About a month after measuring the eight additional objects, he measured three more, M98, M99, and M100, on April 13, 1781.

Thirteen of Messier's 14 nebulae in this region are easily identified, but M91 cannot be found. Is it NGC 4571, as the *New General Catalogue* suggests? Photographs show that this galaxy is much too faint for Messier's small telescopes. Inspection of Palomar Sky Survey photographs shows that Messier was astonishingly successful in locating all the bright galaxies in this area, while he invariably missed the fainter ones. There is simply no bright nebula omitted by Messier that could conceivably be identified with M91.

We look in vain at Messier's description of his 91st object for further clues:

89. $12^h\ 24^m\ 38^s$, $+13°\ 46'\ 49''$
Nebula without stars, in Virgo, a short distance from and on the parallel of declination of the nebula reported above, No. 87. Its light is extremely weak and faint, and it is not possible to detect it without difficulty.

90. $12^h\ 25^m\ 48^s$, $+14°\ 22'\ 50''$
Nebula without stars, in Virgo; its light is as faint as the preceding, No. 89.

91. $12^h\ 26^m\ 28^s$, $+14°\ 57'\ 06''$
Nebula without stars, in Virgo, above the preceding, No. 90; its light is still fainter than that above.

Could this object have been a comet, as H. Shapley and Helen Davis suggested? Possibly, but I believe that another explanation is more likely. In each of Messier's three groups of nebulae recorded in the Coma-Virgo region, the listing proceeds in order of right ascension. One can imagine Messier using a technique frequently employed by amateur observers today. Quite probably he scanned the sky along a north-south line, letting the diurnal motion of the heavens slowly carry the more easterly stars into his telescope's field of view for the next sweep. In this way he could detect the nebulae one after the other, and by timing their transits across a central wire, he could compute their right ascensions.

If this were the case, M91 would be properly identified with the next nebula east of M90 to be caught in the north-south sweeps in declination. Not surprisingly, there is a bright nebula with a right ascension almost exactly the same as M91's — the nebula Messier had recorded two years earlier as M58. Furthermore, the difference in declination is about two degrees. The comparison star used for these nebulae is not known, but presumably Messier determined the declinations by differences, rather than directly from a circle. These objects are so faint and diffuse that Messier must have experienced difficulty in getting precise positions. Considering this uncertainty, it is possible that the error in declination could have been *exactly* two degrees, and thus be accountable as a simple mistake in the reduction of the observations.

Although the evidence is circumstantial, I believe we can reasonably assume that the listing of M91 has resulted from a duplicate observation of M58.

Only for M102, another missing nebula, can the mystery be solved with complete certainty. Soon after the publication of the second supplement to Messier's catalogue, which included M102, Méchain sent a correction to J. Bernoulli in Berlin, explaining that M102 was identical to M101. The confusion had resulted from an error in his star chart. Méchain's letter was translated into German and

NGC 2548 is the cluster the author believes to be Messier's 48th object. It is depicted here on a Palomar Observatory Schmidt plate, the field being a degree wide, with south at the top. According to A. Wallenquist, this galactic cluster contains 56 stars brighter than magnitude 12.7 and is about 1,600 light-years distant.

printed in the *Berliner Astronomisches Jahrbuch* for 1786. The real puzzle here is why this letter was overlooked by so many astronomers for so long.

In 1877, E. Holden included a reference to Méchain's letter in his useful *Index Catalogue of Books and Memoirs Relating to Nebulae and Clusters.* The correction is mentioned even more explicitly by G. Bigourdan in his thorough analysis of old discoveries of nebulae in *Observations, 1907,* of the *Annales* of the Paris Observatory (published in 1917). Nevertheless, other investigators of Messier's catalogue seemed unaware of the correction until 1947, when Helen S. Hogg published Méchain's letter in the *Journal* of the Royal Astronomical Society of Canada. The original French text is found in the *Histoire* of the Berlin academy for 1782, and has been overlooked even longer than its German translation.

We have now seen that, of the 103 objects in the original Messier memoir and its supplements, two are duplications and a third, M40, is a mere asterism. Thus, exactly 100 nebulae and clusters constitute the Messier catalogue.

Méchain included, in his letter that rectified the M102 error, an account of six additional objects, two of which had been briefly noted in Messier's description of M97. This list is sometimes considered as a third supplement, and the objects have been numbered by C. Flammarion, Dr. Hogg, and myself. If Méchain's numbers 104 to 109 are included, then the clusters and nebulae in the Messier-Méchain catalogue total 106.

M101 is a beautiful spiral galaxy of type Sc in Ursa Major. In a letter to J. Bernoulli, P. Mechain pointed out that this object and M102 were identical. This photograph was taken with the Lick 36-inch Crossley reflector in 1899.

The bright galaxy above and to the left of center is M58, in the Coma-Virgo region of the sky where galaxies abound. Owen Gingerich believes M91 was actually a duplicate observation of M58. At the far right is bright M89, while about 1½ inches below and to its left are images of two other galaxies. M58 is a barred spiral of type SBc, and M89 is an elliptical system. Two other spirals are the "Siamese twins," NGC 4567 and 4568, at the lower left, an inch away from an elliptical galaxy. This picture is enlarged from a 74-minute exposure made in 1947 with Harvard Observatory's 24-inch Jewett Schmidt camera. The field is about two degrees wide, with north to the right. A much larger portion of the original plate was reproduced on page 150 of the February, 1955, issue of this magazine.

OBSERVING THE SATELLITES

Echo I over Florida on August 14th, in a three-minute exposure beginning at 9:08 p.m. Eastern standard time, by T. Ferris, Key Biscayne Astronomical Association. Clouds caused fading.

Echo I

THE brightest artificial satellite yet launched, Echo I has attracted unusually wide public interest. Despite its thousand-mile orbital height, the 100-foot aluminized balloon rivals 1st-magnitude stars, catching the attention of even casual watchers.

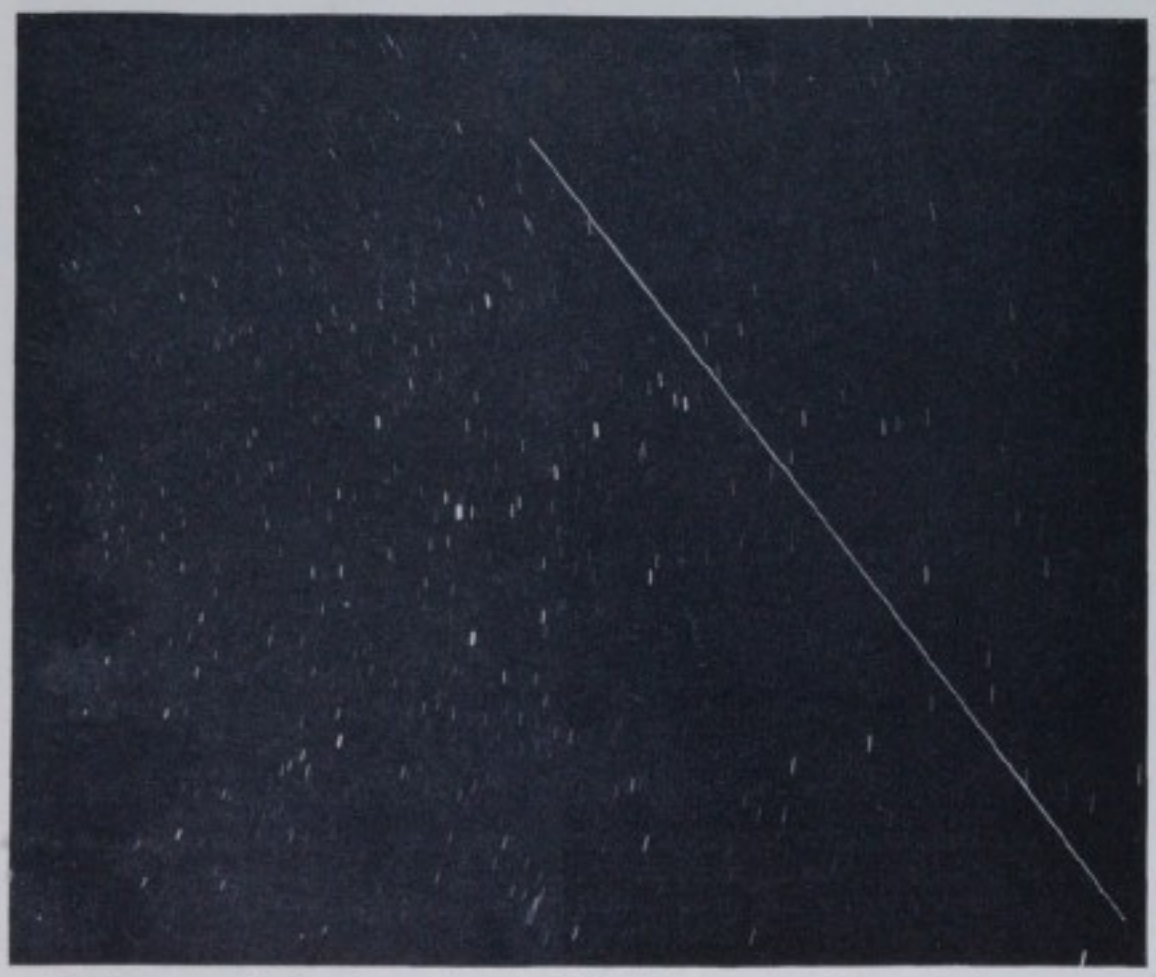
Sent up from Cape Canaveral on August 12th at 8:39:43 UT, Echo I is the first inflatable structure to go into orbit. Three earlier attempts with smaller balloons had miscarried, as well as a full-scale try on May 13th. The Shotput series of five firings of 100-foot balloons from Wallops Island, Virginia, was intended only as inflation tests; while an altitude of 225 miles was reached, orbital velocity was not sought.

The Delta launching vehicle for Echo was designed for interim use while more powerful rockets are being developed. Its first stage is a 50-ton Douglas Thor IRBM, which burns kerosene and liquid oxygen to develop about 150,000 pounds of thrust, powered flight lasting 160 seconds. Its Bell radio guidance system is carried in the second stage.

The Aerojet-General AJ 10-118 engine of the latter ignites almost immediately after the first stage has separated. With its liquid fuel, the second stage weighs over two tons and furnishes some 7,500 pounds of thrust. Powered flight lasts about 115 seconds, and is ended on radio command.

During the 15 minutes of upward coasting that follow, the vehicle rises to an altitude of 800 miles, about 2,300 miles downrange (southeast) from Cape Canaveral. The third stage, an Allegany ABL-248 solid-propellant rocket, is fired after the assembly is given a stabilizing spin of 120 revolutions per minute. This 500-pound rocket furnishes 3,000 pounds of thrust and burns for 40 seconds. Then, after the payload is separated, a tumble rocket is fired to alter the course of the third stage, to prevent a collision.

Paul Roques took this picture on August 16th, at 3:55 UT, at Griffith Observatory in California. He believes it shows irregular reflections from Echo I's distorted surface.

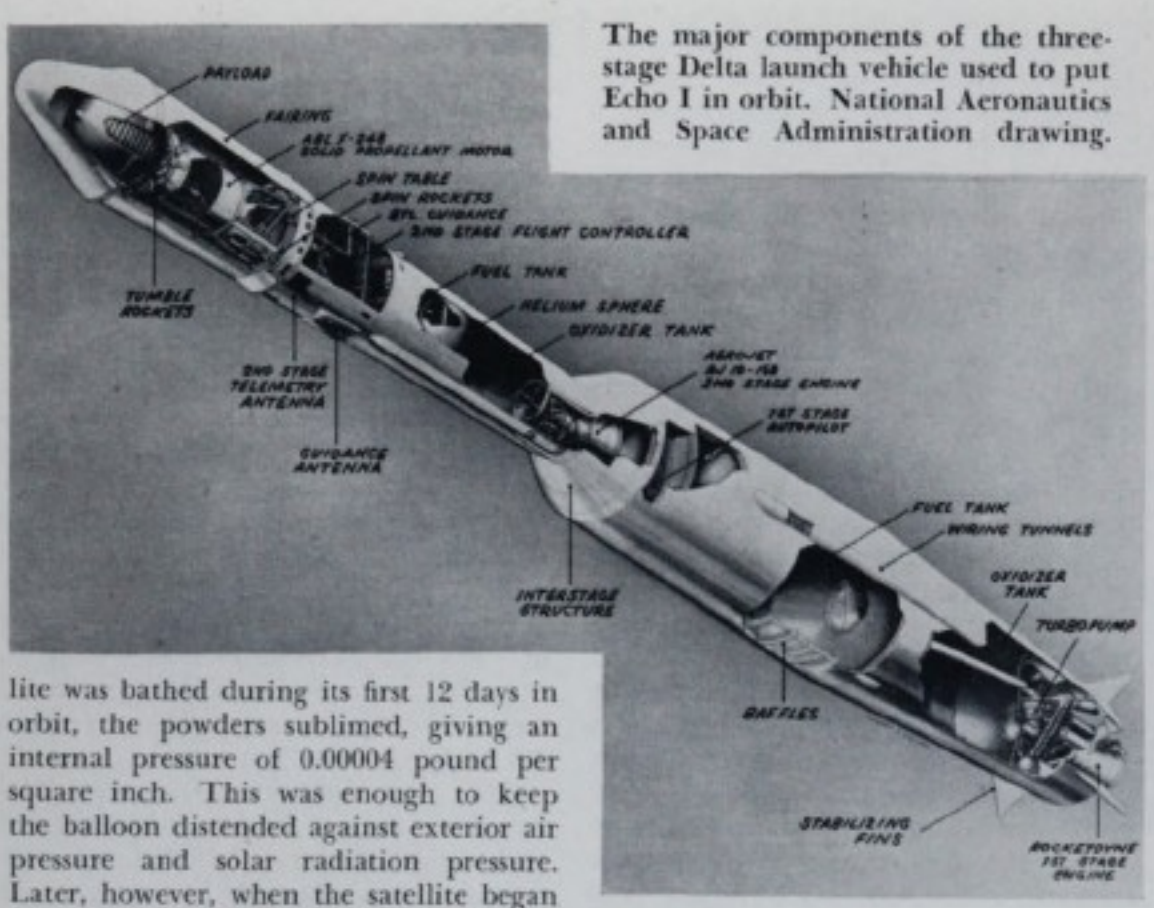


Passing near Cassiopeia on August 16th, Echo I was photographed at 11:47 p.m. EST by P. Donaldson, Arlington, Massachusetts. The bright stars slightly left of center form the familiar constellation in this one-minute exposure.

At this point during the August Echo shot, the payload was over the Atlantic Ocean, in latitude 7° north, longitude 43° west. The two magnesium hemispheres that contained the plastic envelope were parted by a shaped charge, and the balloon began to inflate, under the pressure of the traces of air within it. The balloon itself was made of 82 gores of du Pont Mylar plastic, only 0.0005 inch thick (half the thickness of the cellophane wrapping of a pack of cigarettes).

This plastic bag, weighing 132 pounds, was coated with a 0.000007-inch layer of aluminum, giving a reflectivity of 98 per cent for radio frequencies up to several thousand megacycles. This coating weighed only four pounds.

Dusted inside the envelope before it was folded accordion-fashion within its container were 10 pounds of benzoic acid and 20 pounds of anthraquinone. Warmed by continuous sunlight in which the satel-



The major components of the three-stage Delta launch vehicle used to put Echo I in orbit. National Aeronautics and Space Administration drawing.

lite was bathed during its first 12 days in orbit, the powders sublimed, giving an internal pressure of 0.00004 pound per square inch. This was enough to keep the balloon distended against exterior air pressure and solar radiation pressure. Later, however, when the satellite began spending part of each revolution inside the earth's shadow, the internal temperature would drop so low that the vapors would temporarily condense.

A major problem is posed by leakage from meteorite punctures. According to scientists of the National Aeronautics and Space Administration, about 1.4 square inches of perforation would be expected each day, on the average. During the first days aloft, when the earth was carrying the satellite with it through the Perseid meteor swarm, the rate may have been six times greater. The anthraquinone had been added to provide makeup gas, in order to balance these leakages.

On the balloon's surface, two tiny tracking transmitters are attached at opposite ends of a diameter. Operating at 107.94 megacycles, each transmits 10 milliwatts of power, obtained from solar cells. They are interconnected by a printed circuit on the surface of the sphere.

As told on page 222 of Sky and Telescope for February, 1960, the principal use of the Echo satellite is in radio communications experiments, in which reflection from the 100-foot sphere is used to relay signals beyond the curve of the earth. The expected performance has been attained to within a few decibels. A great variety of tests, both by official contractors and volunteer groups, are now being conducted with many types of communications equipment, for measuring the amplitude, frequency shift, phase, and polarization of the reflected signals.

Because of its vast size and light weight, Echo I's motion is providing a much more sensitive measure of atmospheric drag than a conventional satellite could. Thus, the balloon can be expected to give valuable information on atmospheric density at the 1,000-mile level. Even the pressure of sunlight has an observable effect on the orbital motion of Echo I, lowering its perigee height by 1½ miles per day in late August. This is in agreement with theoretical predictions.

According to Space Track, on August 31st the orbital period of the Echo I balloon (1960ι1) was 118.2 minutes, and the height varied between 1,057 miles at apogee and 937 miles at perigee. For 1960ι2, the third-stage rocket, the corresponding figures are 118.0 minutes, 1031 and 950 miles. The two orbits are inclined 47.20 and 47.28 degrees, respectively, to the earth's equator.

Recovery from Orbit

An important objective that had often eluded success was attained three times within the span of a few days, when the United States recovered two Discoverer capsules from orbit on August 12th and 19th, and Russia brought down safely a cabin with living animals on August 20th. This rapid succession of achievements, together with the launching on August 12th of the brightest artificial satellite so far, Echo I, made this month one of the most exciting to date in the space age.

In 12 earlier Discoverer shots, seven attempts to place a satellite into orbit are officially counted as successful. In five instances, the capsule was separated from the satellite, as shown by telemetered data, but no recovery was made by the United States. In the Discoverer II experiment, the descending parachute was observed over Spitzbergen, but neither Norwegian nor U. S. Air Force teams could find the capsule.

The capsule from Discoverer V remains in orbit around the earth, having been wrongly oriented when its retro-rocket fired. More recently, a similar mishap prevented recovery by Soviet technicians of the cabin of Sputnik IV, which also continues to circle the earth. These many failures emphasize the difficulty of the recovery problem, especially for the Discoverer program, where the relatively small Thor IRBM booster greatly limits the weight of equipment that can be carried to facilitate recovery operations.

Discoverer XIII was launched from

R. E. Cox, O'Fallon, Missouri, recorded two successive passages of the Echo I satellite on the night of August 21-22. The five-hour exposure with a 50-mm. Xenon f/1.9 lens was begun at 10:15 p.m. Central daylight time. The 11 p.m. passage (upper one at the left) and the 1 a.m. passage show the effect of the earth's rotation upon apparent paths of the satellite. Intermittent light clouds late in the exposure caused the star trails to become broken. The bright image at bottom center is Polaris, and the stars of Draco and Cepheus are above. A faint meteor trail was recorded on the original negative, to the right of the pole star.

Vandenberg Air Force Base, in California, on August 10th at 20:37:54 Universal time. Low fog over the base required the use of a new radar system for tracking the first few miles of powered flight. The Agena second stage went into a 94.1-minute orbit, inclined 82.85 degrees to the earth's equator. Its payload was a re-entry capsule weighing 350 pounds.

During its 17th revolution, on August 11th at 23:13 UT, the Agena was traveling southward toward the Bering Sea, at a height of about 200 miles over latitude 70° north, longitude 176° west. At that time, a radio signal transmitted from Kodiak, Alaska, fired the explosive bolts holding the capsule, permitting its separation.

Inside the capsule were some 100 pounds of monitoring equipment, intended to aid in the diagnosis of recovery problems. This apparatus recorded and telemetered events beginning with the ejection of the capsule from the Agena, and the former's subsequent spinup to one revolution per second by a system of cold gas jets. Then the retro-rocket fired, and the gas jets oriented the capsule so that its ablative heat shield would take the brunt of aerodynamic heating during re-entry into the denser atmospheric layers.

The telemetered signals were blacked out for a couple of minutes as the capsule generated ionization along its path from 75 to 25 miles above the earth's surface. At that time, the temperature of the nose cone was rising toward 4,000° Fahrenheit, and the deceleration force may have amounted to 15 times gravity.

Later, the spent retro-rocket and the heat shield were jettisoned, and a quantity of aluminum tinsel was ejected to aid radar tracking. Finally, the 30-pound parachute opened at an altitude of about 10 miles, to lower the capsule, now weighing 120 pounds, through the denser troposphere.

High clouds hampered the lookout by aircraft circling over the Pacific, as the capsule drifted down to the sea, about 300 miles northwest of Hawaii. But its radios were operating, and its progress was tracked from land, ship, and plane. At about 0:05 UT on August 12th, the floating capsule was first spotted from a C-119 Flying Boxcar, which summoned one of the recovery ships to the area. The latter dispatched a helicopter carrying a Navy frogman, who was able to attach a cable to the capsule at about 2:15 UT. Subsequently, it was flown to Hawaii and to California for study, before going on public display in Washington, D. C.

The second stage of Discoverer XIII remains in orbit as 1960ι. On August 31st, its period amounted to 93.4 minutes, with an apogee height of 392 miles and a perigee of 153 miles, according to Space Track.

The fourteenth Discoverer, similar in most respects to XIII, was launched on August 18th at 19:58:01 UT. The Agena second stage became artificial satellite 1960κ, with an orbital inclination of 79.67 degrees and an initial period of approximately 94.5 minutes. Its orbit was more eccentric than Discoverer XIII's, and perigee height was only about 112 miles.

Shortly after the Agena went into orbit, a wobble developed, and for a time it was feared that the satellite's supply of high-pressure gas would be exhausted before the vehicle's orientation could be stabilized. Actually, enough gas was left to reorient the Agena for capsule ejection.

This time, also, the recovery sequence was begun during the 17th revolution, but relatively later in it, so the capsule came down farther south, some 300 miles south-southwest of Hawaii. Again, C-119 aircraft were circling the recovery area, and the crew of one plane heard signals from the radio beacon of the re-entering capsule at 22:53 UT. Thirteen minutes later, flying at 8,500 feet, this plane on the third try successfully snared the descending parachute, with a grappling hook attached to a trapezelike recovery rig.

The Discoverer XIV capsule carried a payload differing from its predecessor's. It included experimental equipment for the Midas and Samos satellite systems, which are intended for detecting missile launchings and for photographic reconnaissance, respectively.

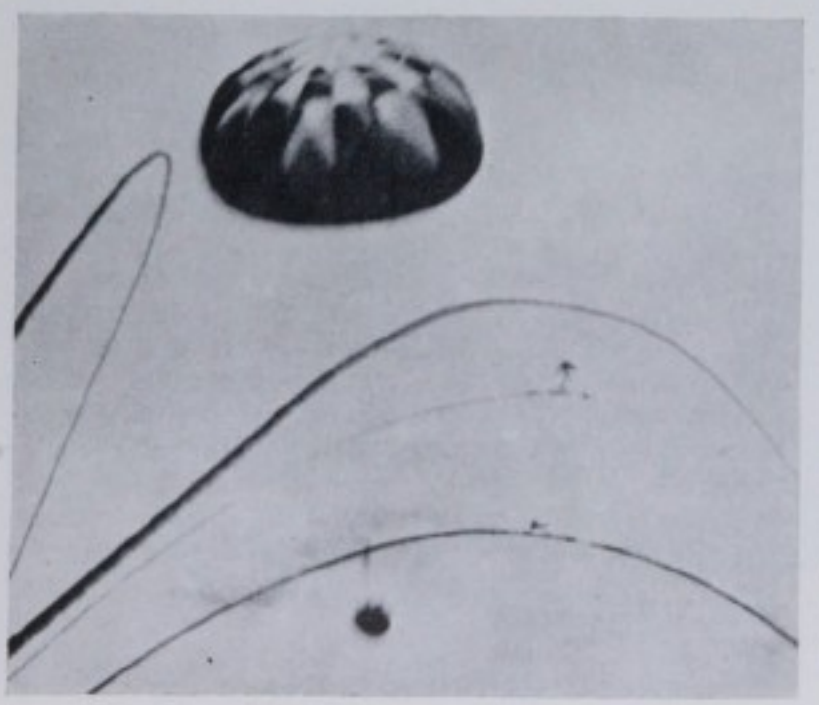
To assist the Navy's Transit navigation program, the Discoverer XIV satellite carried a 10-pound tracking experiment, consisting of a Doppler beacon and external lights. Four Baker-Nunn cameras of the Smithsonian Astrophysical Observatory — at Villa Dolores, Argentina; Curacao, Netherlands West Indies; Jupiter, Florida; and Maui, Hawaii — successfully photographed these lights on August 19th. This was the first time that an artificial satellite had ever been observed optically except by reflected sunlight (or when on its final plunge to earth).

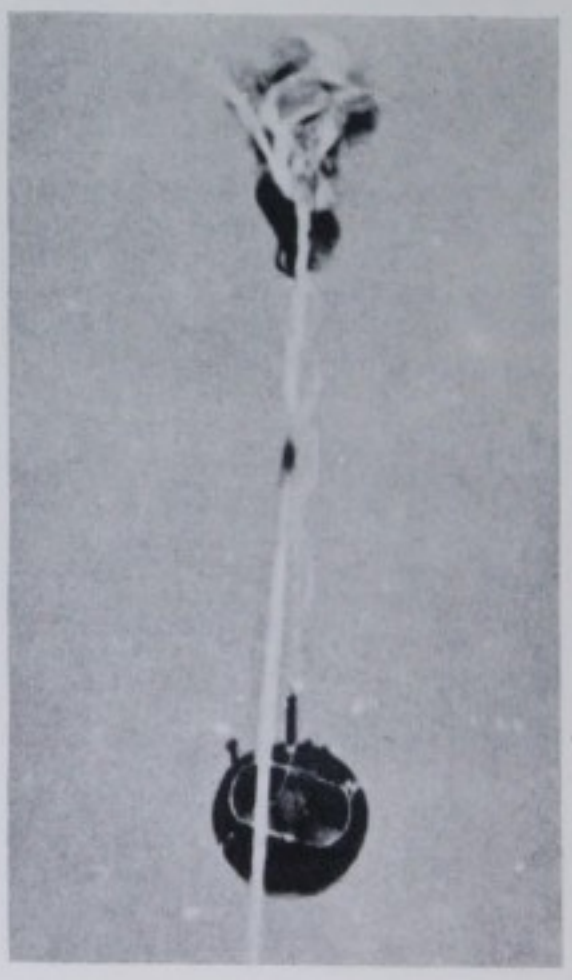
By the last day of August, the period of 1960κ had decreased to 93.0 minutes, according to a Space Track announcement. The apogee and perigee were then 407 and 111 miles, respectively.

Only a few hours after Discoverer XIV was sent aloft, a Soviet announcement told of the launching of 1960λ1, a 10,140-pound spaceship carrying live animals and plants. No indication of the time or place of launching was given. At an unstated time on August 20th, during its 18th revolution, the massive vehicle was successfully returned to earth. Remaining in orbit was 1960λ2, the final stage of the rocket.

Few details are known of this achievement. From statements in the Soviet press, this vehicle resembles the one launched on May 15, 1960. In western countries, the name Sputnik V is widely used for this latest short-lived satellite.

Its most publicized passengers were the two dogs Strelka and Belka, specially trained to meet the conditions of space travel. Also carried were many mice and rats, fruit flies and possibly other insects.





Left: This picture, taken from the C-119 recovery plane, shows the grappling equipment just missing the parachuting Discoverer XIV recovery capsule on the second try to snatch it in mid-air.

Right: The successful third try is shown here. A grappling hook has secured the capsule and its parachute, and a winch aboard the airplane is slowly reeling in the equipment to complete the recovery operation. U. S. Air Force photographs.

and seeds of maize, wheat, and peas. In addition, there were biological preparations of chlorella cells, fungi, bacilli of several kinds, bacteriophages, skin sections, cancer cells, and desoxynucleic acid.

This varied collection should give much information about the effects of the space environment on living organisms. Though high-altitude rockets have been used for biological experiments, and Sputnik II carried the dog Laika aloft, the new specimens are the first survivors of an orbital trip that are available for subsequent laboratory study.

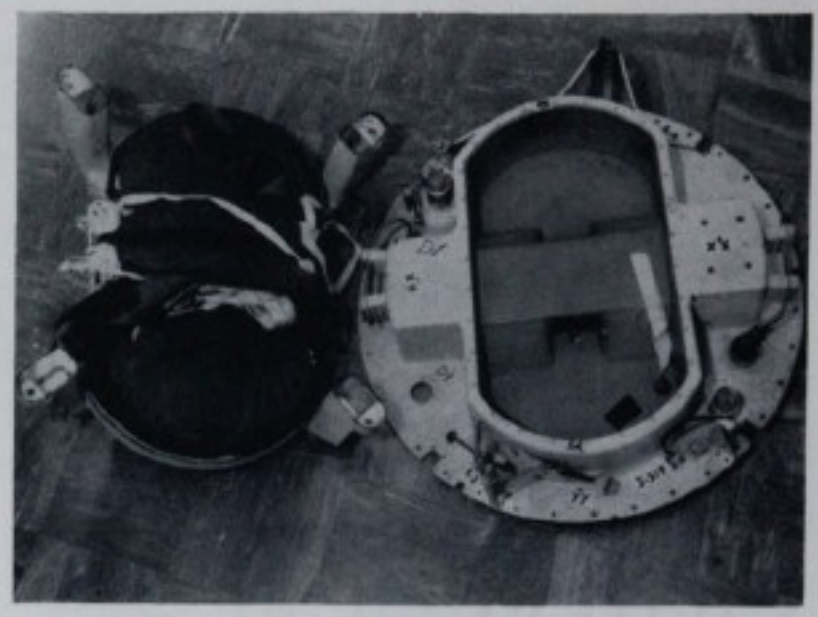
During the flight of Sputnik V, its two dogs were observed by television, and their respiration, heart rate, blood pressure, and electrocardiograms were monitored. Telemetered data showed that the spaceship cabin maintained suitable levels of temperature, air pressure and composition, and humidity.

Geophysical investigations were also carried out with the aid of Sputnik V. Ultraviolet and X-ray radiation from the sun were measured, together with cosmic ray dosage, and details of the cosmic ray spectrum.

Sputnik V traveled in an orbit inclined 64.9 degrees to the earth's equator, with a period of about 90.7 minutes, according to Space Track. Soviet scientists state that its orbit was the most nearly circular of any artificial satellite to date, with a height of approximately 200 miles above the earth's equator.

Practically no detailed information is available about the recovery. One press report states that the spaceship and its ejected cabin landed separately, the latter only seven miles from the predicted spot. Some accounts indicated that the ship came down on land. If so, it appears that within an interval of only about 10 days, successful satellite recoveries were made from water, air, and land.

MARSHALL MELIN
Research Station for Satellite Observation
P. O. Box 4, Cambridge 38, Mass.



The recovery gear and parachute used in the Discoverer XIII flight test, photographed prior to its installation in the Agena vehicle launched on August 10th from Vandenberg Air Force Base in California. In addition to a radio beacon, flashing lights were included to aid air and surface recovery operations. U. S. Air Force photograph.

QUESTIONS... FROM THE S+T MAILBAG

Q. Why do some telescopes give colored images of the moon and bright stars?

A. Because they have the optical defect known as chromatic aberration, illustrated by the failure of a simple lens to bring light of different colors to the same focus. A standard refractor's two-element objective glass always introduces some color effect, but a three-element objective can be made practically free of color – hence, it is called apochromatic. In an optical system employing only mirrors, there is no chromatic aberration.

Q. Why are some of the extended nebulosities in the sky observable only by photography?

A. Because they are too faint to be seen by the visual observer, whose eye cannot add up the impressions it receives over an interval of time. The very weak images are built up, however, during a long-exposure photograph.

Q. How bright will Encke's comet become on its next return?

A. When brightest, around the date of perihelion (February 5, 1961), this comet will be too nearly in line with the sun to be observed. In mid-January, the comet will be about magnitude 8, in Aquarius; in mid-February, magnitude 6 in southern Capricornus.

Q. How often do transits of Mercury across the sun's disk occur?

A. About 14 times each century, on the average. The next one is on November 7th of this year and will be visible in the United States (see page 214).

Q. At what rate are new variable stars being discovered nowadays?

A. Between 100 and 200 in a typical year, mostly through photographic searches at German and Russian observatories.

Q. How rapidly is meteoric dust accumulating on the moon's surface?

A. About one gram per square centimeter in 100 million years, according to a recent estimate by E. Opik.

Q. I am considering building a concrete platform on which to use my portable telescope. Is there a drawback to this?

A. Yes; with higher powers, such as are employed on the moon and planets, image quality may be poorer than if the same telescope were standing on grass. During evening hours, air currents rise from the sun-warmed concrete; they are absent over grass.

Q. During an eclipse of the moon, why are the times of full moon and mid-eclipse usually not the same?

A. Lunar eclipses occur when the moon is near one of its nodes, and thus moving at an angle of about five degrees to the ecliptic. Hence, unless the eclipse is perfectly central, the moment when the moon is nearest the center of the earth's shadow (mid-eclipse) is not the same as that when the moon is exactly 180 degrees of celestial longitude from the sun (full moon).

W. E. S.

LIGHT-BEAM AMPLIFIER

A new solid-state electronic device, smaller than a water tumbler and containing a synthetic ruby as its heart, is the means by which American scientists have succeeded in amplifying a beam of light into a concentrated coherent source brighter than the center of the sun. Theodore H. Maiman, Hughes Aircraft Co., has disclosed the essential steps in the operation of the *laser*, a coined word for "light amplification by stimulated emission of radiation."

A high-temperature light source irradiates the ruby crystal, which absorbs energy over a broad band of frequencies. The ruby atoms are excited, and remain in this state until an optical resonator stimulates them to emit together a beam of very narrow wave length at 6943 angstroms. In theory, this radiation can be a million times more nearly monochromatic than that of a mercury or neon spectral line.

Such coherent light is radiated in an almost perfectly parallel beam, and therefore may be focused to a small spot; it does not diverge and diffuse as do beams from ordinary light sources. The bundle of rays could illuminate an area less than 10 miles wide if projected to the surface of the moon, according to Dr. Maiman. In comparison, a conventional spotlight would illuminate a width of 25,000 miles were it projected to the same distance.

The laser opens a new domain in scientific research and communications. The light beam of high effective temperature may be used to examine properties of matter and to vaporize individual parts of bacteria and other microorganisms. The possibilities for communication directed along such narrow intense beams are especially good in space, where there is no atmosphere to absorb or scatter the radiation.

The 11th annual convention of the Western Amateur Astronomers at San Jose, California, on August 27-28, 1960.

Convention at San Jose

ALAN MCCLURE, *Los Angeles Astronomical Society*

Convention delegates line up for a view of Jupiter through the 36-inch refractor at Lick Observatory. Photograph by Alan McClure.

ABOUT 300 amateurs from as far as Hawaii and Cuba attended the 11th annual convention of the Western Amateur Astronomers on August 25-27 at San Jose, California. Our hosts were the San Jose Amateur Astronomers and the Peninsula Astronomical Society, with Walter J. Krumm serving as general chairman.

Preceding the WAA sessions, all-day meetings were held by the Western Moonwatch, on August 23rd, and the Association of Lunar and Planetary Observers, on the 24th. Mrs. Vi Hefferan, of the Albuquerque, New Mexico, high school Moonwatch team, told of that group's activities and the interest in science this has created among the students. She stated that the team has obtained excellent financial support from local individuals and business firms.

There were 18 papers at the ALPO session. Dr. Dinsmore Alter, former director of the Griffith Observatory and Planetarium, discussed the capture theory of the moon's origin, showing how tidal forces associated with such a process would result in many maria being formed on the lunar side nearest the earth.

The San Jose municipal auditorium was the setting for the WAA sessions. After the preliminary ceremonies, Leif A. Robinson, Los Angeles, gave suggestions for amateur observations by photography and other techniques, in addition to drawing. Gains in the rapid exchange of satellite information since the formation of the Western Satellite Research Network in 1959 were described by Arthur Leonard. Observing efficiency has been increased, and the labor of searching for new or lost objects has been cut.

Thursday's main speaker was H. Julian

The right-hand half of the picture that begins on the opposite page. Group photograph courtesy Joseph A. Marchisella.

Allen, assistant director of the Ames Research Center, who discussed the physics of meteors, comparing the behavior and physical properties of iron and stony meteors. Movies were shown of laboratory tests, with frozen pellets of oil and acetone in supersonic tunnels, that produced markings similar to those found on the respective types of meteorites. That afternoon there was a field trip to the center, a division of the National Aeronautics and Space Administration, at Moffett Air Force Base, where delegates inspected the huge wind tunnels and other installations.

In the evening, a picnic supper was held at Lick Observatory atop Mt. Hamilton (see front cover). The new 120-inch reflector and the 20-inch Carnegie astrograph were visited. As dusk approached, the 36- and 12-inch refractors were made available for viewing celestial objects. Dr. A. E. Whitford, the observatory's new director, guided a number of tours and was on hand until nearly midnight to answer our many questions.

David L. Webster of Palo Alto opened Friday's session with a discussion of different materials that would produce bright rays on the moon's surface. Reference was made to the hairlike volcanic glass called Pele's hair. A multiple-eyepiece Moonwatch telescope which minimizes the number of instruments required by a team was described by Jack A. Borde of Concord. Excellent time-lapse pictures of solar prominences and flares taken at the Lockheed Solar Observatory were shown by George Carroll. The observatory has discovered that if the H-alpha filter passband is shifted toward the blue about one angstrom, a dark surge precedes a flare in about 40 per cent of the cases.

The first Morrison lecture was on radio astronomy at Stanford University, by Dr. Govinda Swarup. He told of the 14-acre rhombic antenna that was used to bounce a radar echo off the sun last spring. After lunch, the delegates motored by bus to the Stanford radio research installation, where Dr. Swarup showed us the 375-foot cross being employed in the 9-centimeter range for solar studies, as well as the huge yagi array, which covers hundreds of acres.

A huge crowd attended the public star party on Friday evening at the Santa Clara County Fairground. We brought telescopes ranging from exotic types to a "plumber's nightmare."

The final day opened with a description of a 10-inch reflector-corrector telescope by S. Neuman of Palo Alto. Photographs were shown by Don Cone of the re-entry of an Atlas missile nose section, taken when he happened by chance to view this phenomenon while flying from Tokyo to Wake Island. Robert Samples, Denver, Colorado, illustrated his talk on the evolution of the earth and sun with color slides of his beautiful paintings. The breathtaking color movies of Jupiter, Saturn, and Mars, obtained with the 60-inch Mount Wilson reflector by Robert Leighton, California Institute of Technology, were so enthusiastically received that they were presented twice.

A discussion of a satellite-borne telescope that would have a useful life of about one year was given by Robert Crane, chief of Ames' aerothermodynamics division. Astronomical observing requirements have been the key to its design. The biggest problem has been directing the telescope's aim to within one second

One of the highlights of the WAA meeting was a visit to Mt. Hamilton and Lick Observatory. Prior to touring the many astronomical installations there, the group gathered for a picnic. Left to right are Thomas Cragg, a staff observer at Mount Wilson Observatory, Claude Carpenter, Ralph Edwards, Leif Robinson, Jack Eastman, and Geoffrey Gaherty, Jr., who was visiting from Montreal, Canada. This picture was taken by the author.

of arc, and much work has centered on control systems for this.

In the second Morrison lecture, Dr. William P. Bidelman explained why the telescopes of Lick Observatory are employed for visual observations only five to 10 per cent of the time — they are occupied mainly with spectroscopy. He showed a number of spectrograms, including high-dispersion ones of peculiar stars.

The banquet speaker was Dr. Alfred J. Eggers, Jr., of Ames Research Center, who explained Project Mercury — putting a man into space. An ALPO award was given to Thomas R. Cave, Jr., of Long Beach, and the Blair medal to David P. Barcroft, Madeira, well known for his lunar studies. Long Beach has been selected as next year's meeting place.

Mr. Cave was named the new chairman of the WAA, and Mrs. Ruby Perkins, La Canada, secretary. The convention proceedings, at $1.50 per copy, and the group photograph, $1.00, are available from Mr. Krumm, 10628 Larry Way, Cupertino, Calif.

+++ Amateur Briefs +++

A deep loss to the Great Plains Astronomical Society was the death in May of one of its founders, Milo G. Mather of Clarksville, Iowa. His family has given his observatory, including its 27-inch reflector, to Iowa State University as a memorial to him.

The Grand Rapids Amateur Astronomical Association was invited by the town of Lowell, Michigan, to hold a star party on September 9th for its 3,000 citizens.

The Astronomers Guild of Jamestown, New York, has completed grinding and correcting, to 1/16 wave, a 24-inch telescope mirror of the Cassegrain type, f/4, with an 8-inch secondary. A mounting is now under construction, and an observatory will be built to house the instrument.

Alpha Coronae Borealis was picked as the city of Yakima's diamond-jubilee star by the Yakima Amateur Astronomers in Washington. Light now seen from that star started on its way to the earth about the time the city was founded 75 years ago. During a recent week-long celebration, the society had an appropriate exhibit concerning this and other astronomical topics.

Observing is difficult these days at the observatory of the Allegheny Valley Amateur Astronomers Association in Springdale, Pennsylvania. A used-car sales lot opened directly across the street from the building, and its bright lights interfere with star study!

A "nova" denotes a new member in the Palomar Amateur Astronomers of Escondido, California. Juniors are called "comets," and club boosters, "1st-magnitude friends." The society also has a few "sub-dwarfs," those members who are "getting too dim on the records."

H. M. C.

Amateur Astronomers

THIS MONTH'S PROGRAMS

Glen Burnie, Md.: Chesapeake Astronomical Society, 8 p.m., Harundale Presbyterian Church. October 14, motion picture, Our Sun.

Honolulu, Hawaii: Hawaiian Astronomical Society, 7:30 p.m., Waikiki-Kapahulu Library. October 6, George W. Bunton, California Academy of Sciences, "Is There Life on Other Planets?"

New Orleans, La.: Pontchartrain Astronomy Society, 8 p.m., Loyola University physics building. October 7, Dr. Frank Benedetto, S. J., Loyola University, "The Meeting Between Astronomy and Physics."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. October 5, Dr. Charles P. Olivier, Flower and Cook Observatory, "The Stars Fell."

New York, N. Y.: Junior Astronomy Club, 8 p.m., Waverly building, New York University. October 21, Dr. Dean B. McLaughlin, University of Michigan Observatory, "Volcanic Theory of the Surface of Mars."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. October 1, Dr. Francis J. Heyden, S. J., Georgetown University Observatory, "The Spectroscopic Program of Georgetown University."

A MASSACHUSETTS OBSERVATORY

Since my Quonset-hut home is completely surrounded by trees, I have built my observatory nine feet above ground level. The enclosure, constructed of $\frac{1}{4}$-inch plywood, measures eight feet square. Its top rolls on eight $1\frac{1}{4}$-inch nylon wheels and aluminum track. A center post, completely independent of the floor, supports my 6-inch reflector.

Many visitors, including students from the local school, have come to my observatory since it was completed last fall. I am a member of the South Shore Astronomical Society.

RALPH W. WALKER
Snipatuit Rd.
Rochester, Mass.

AAVSO FALL MEETING

The American Association of Variable Star Observers will hold its annual fall meeting at the Springfield, Massachusetts, Museum of Science on October 14-15. On Friday evening, Cyrus Fernald will speak on problems he encountered in reaching his total of 100,000 variable star observations.

BOSTON ASTRONOMY CLASSES

An eight-week nonmathematical introductory course in astronomy will be given at the Charles Hayden Planetarium in Boston, Massachusetts, beginning Tuesday evening, October 4th. The tuition is $8.00 for museum members, $10.00 for nonmembers.

Starting Thursday evening, November 3rd, and continuing for six weeks, the planetarium will offer an introductory astronomy course for elementary and junior high school teachers. The fee is $6.00 for museum members and $7.00 for others, with an additional $3.00 for materials. Both classes are to be conducted by John Patterson, planetarium director.

Further information is available from the planetarium, Boston Museum of Science, Science Park, Boston 14, Mass.

When opened, the sliding roof of Ralph W. Walker's observatory at Rochester, Massachusetts, is supported by the top of his Quonset-hut home.

ASTRONOMICAL SCRAPBOOK

Some Thoughts on Twilight

EVERY enthusiastic observer knows the pleasant feeling of anticipation, on a cloudless early evening, as he waits under a gradually darkening sky until he can begin his night's program. His telescope has been readied and other preparations attended to, so there is leisure to watch the stars coming into view, one after the other in the gathering dusk, and to see the constellations take form.

While the sun sinks below the western horizon, in the east rises the grayish blue shadow of the earth. Just above it is a purplish arc, merging gently into the deep blue of the sky. As the earth's shadow mounts higher into the eastern sky, its initially well-marked upper boundary grows less distinct, usually becoming unrecognizable by the time the sun is 12 degrees below the horizon. Simultaneously, the purple border has been fading away.

Meanwhile, in the west, the bright yellows and reds have vanished, and a purple glow appears, covering much of the western sky. As the darkness deepens, this glow fades and contracts; its final disappearance on the western horizon marks the end of astronomical twilight and the beginning of true night.

The length of time between sunset and the close of twilight varies with the time of year and with geographical latitude. Thus, at the latitude of Philadelphia, Pennsylvania, astronomical twilight lasts two hours in late June, but only 90 minutes at the times of the March and September equinoxes, when the path of the setting sun crosses the horizon most steeply. At the earth's equator, each year contains about 4,400 hours of day, 850 of twilight, and 3,500 of night, whereas at the North and South Poles the corresponding numbers are about 4,450, 2,400, and 1,900 hours.

The predictions of astronomical twilight in the *American Ephemeris* and elsewhere are based on the rule that evening twilight ends and morning twilight begins when the center of the sun's disk is 18 degrees below the horizon. Of all the varied observational data from which the *Ephemeris* is computed, this 18-degree figure is the hoariest, as it dates back to Claudius Ptolemy — about A.D. 130!

Many early astronomers made their own determinations of this number. Kepler (1618), Gassendi (1647), and J. H. Lambert (1760) all agreed with Ptolemy in assigning a solar depression of close to 18 degrees for the end of astronomical twilight. But the Portuguese scientist Nonius, in his book of 1542 on twilight, preferred 16 degrees, and the German Rothmann cited 24 degrees in a letter he wrote to Tycho Brahe in 1588.

Much more trustworthy was the result announced in 1864 by J. F. J. Schmidt, the famous selenographer who was director of Athens Observatory. The city of Athens was beginning to illuminate its streets by gas, and the mayor asked him for information on when the lights should be turned on and off. From a series of 170 timings when the last vestiges of twilight color vanished on the western horizon, Schmidt found 15.9 degrees for the average depression of the sun.

For many practical purposes, it is more convenient to consider civil twilight, the interval after sunset or before sunrise during which everyday activities are possible without artificial light. By convention, it is defined as ending in the evening or beginning in the morning when the center of the sun's disk is six degrees below the horizon. An approximate statement of this rule is embodied in the motor-vehicle laws of many states, which require that automobile headlights be turned on half an hour after sunset.

In the past, several other definitions of the end of civil twilight were widely used. Looking back and forth between the bright western sky and the darker eastern heavens, it is possible to locate roughly an imaginary line where the intensity gradient is steepest. Lambert timed the passage through the zenith of this line, the so-called crepuscular arc, to find that civil twilight ended when the solar depression was 6.4 degrees.

Also, the end of civil twilight was sometimes described as the moment when it became no longer possible to read a printed page outdoors. Using a copy of this magazine for the experiment, I found that this time seemed definite to within a few minutes, and corresponded to the sun being 7.2 degrees below the horizon.

Closely akin to the problem of the duration of twilight is the question of the visibility of stars and planets during dusk. One of the most complete studies of this was by Schmidt, reported in his paper of 1864.

To decide whether a particular star is visible in a bright, blank sky, it is necessary to know just where to look. Otherwise, you will record not the time of first visibility, but merely the time when you happen to scan the exact spot. Hence Schmidt first brought the star inside the field of view of his telescope, then sighted along the tube with the unaided eye from time to time until the star was seen. In this way, he established that Vega, Capella, and Arcturus could first be detected when the sun was still ¾ degree above the horizon. Similarly, 2nd- and 3rd-magnitude stars were first visible when the solar depression was 4.3 and 5.1 degrees, respectively.

The observations become simpler for fainter objects, for once the stars down to magnitude 3 are visible to the naked eye, the positions of dimmer ones can be located by alignment. Thus, Schmidt was able to recognize 4th-, 5th-, and 6th-magnitude stars when the sun was 6.8, 8.9, and 11.6 degrees, respectively, beneath the horizon.

Very different figures can be found in older books. According to both Ptolemy and Kepler, 1st-magnitude stars could not be seen until the sun was 12 degrees down, and J. F. Wurm in 1782 found that a solar depression of 6½ degrees was needed. The fact that Schmidt could see stars like Vega before the sun had set suggests that his forerunners had not taken special precautions to be looking in the exact directions of the stars.

For the amateur who wants to make visibility tests, it is simpler to do the observations during morning rather than evening twilight, and to time when particular stars disappear in the growing dawn.

The visibility of stars in moonlight is a related topic worth examination.

A century or two ago, it was thought that detailed observations of twilight might provide valuable information about the inaccessible high atmosphere. Nowadays, other and far more effective ways are being used to probe the upper air. Nevertheless, the varied and beautiful phenomena of twilight remain of interest for their own sake.

JOSEPH ASHBROOK

SHATTER CONES AND METEORITE IMPACTS

Meteorites have never been found in geologically ancient rocks, probably because they were destroyed by weathering. However, a large meteorite striking the earth at a speed of 10 miles per second generates an intense shock wave that may spread through a great volume of rock. Does this process produce any geological features that can be recognized many millions of years later as due to meteoritic impact and no other cause?

In the June 17th issue of *Science*, Robert S. Dietz suggests that shatter cones are such an indication. These are conical masses of fine-grained rock, ranging in size from a half inch to 40 feet, and having characteristic striations. Similar forms have been produced artificially by underground nuclear blasts and by large test explosions of TNT.

Dr. Dietz has found thousands of shatter cones and their fragments in an area two miles in diameter, about 20 miles south of Ft. Stockton, Texas. They have also been recognized at seven other localities in the United States, Germany, and Ghana. If, as he proposes, shatter cones are a specific criterion, these eight places are sites where large meteorites fell in the remote past.

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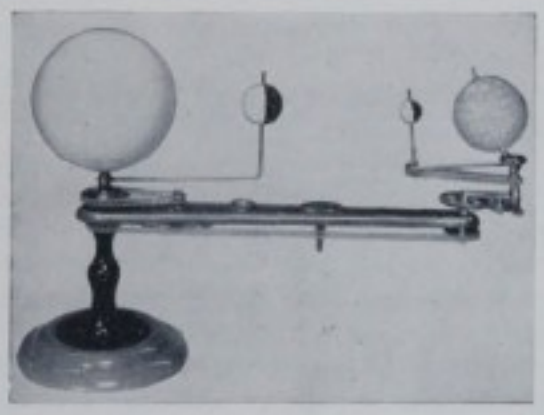

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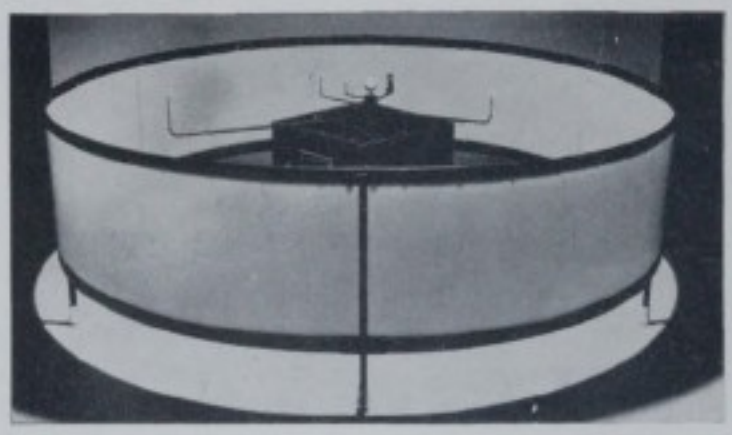

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HERE AND THERE WITH AMATEURS

The societies listed here are all open to the public. Most of them hold regular meetings once or twice monthly. Details of each society's program can be obtained from the official whose name and address are given here.

*Members receive *Sky and Telescope* as a privilege of membership.
†Member organization of the Astronomical League.
‡Member organization of the Western Amateur Astronomers.
°Society has junior section.
‖Independent junior society.

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Birmingham Astronomy Club *†
D. Hall, 100 Oak St., Trussville. GL 4-3117

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Tucson Astronomical and Astronautical Assn. *†‡
D. Strittmatter, 1840 E. Lee St. EA 5-9453

ARKANSAS

LITTLE ROCK
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°CALIFORNIA

BURBANK
Burbank Astronomical Society
D. Rhoades, 1474 N. Evergreen St. TH 8-5880

CHINA LAKE
China Lake Astronomical Society *
C. Evans, Jr., 109-S Blandy. RI 5-0111

CONCORD
Mt. Diablo Astronomical Society *
P. Schroth, 3119 Windsor Pl. MU 2-2090

ESCONDIDO
Palomar Amateur Astronomers *‡
M. A. Sloan, 2418 Alexander Dr. SH 5-7336

EUREKA
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W. N. Abbay, Jr., 1745 Margaret Lane, Arcata. VA 2-4403

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Astronomers of Southern Humboldt
W. Shreeve, Box 862.

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B. Sproul, 130 5th St.

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Los Angeles Astronomical Society, Inc. ‡
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Mrs. S. Burke, 1528 E. 31st. KE 6-0691

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Mrs. E. Patterson, 2842 Fremontia Dr., San Bernardino. TU 3-0565

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H. E. Kaiser, 4868 Hedrick Ave., Arlington. OV 9-2574

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Sacramento Valley Astronomical Society *‡
Mrs. H. Smith, 1608 48th St. (19). GL 1-1483

SAN ANSELMO
Marin Astronomical Society *‡
N. Ash, 1554 Sir Francis Drake Blvd. GL 6-0233

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San Diego Astronomical Society ‖
D. Poole, Jr., 1601 Robinson Ave. (3). CY 7-1092

SAN FRANCISCO
San Francisco Amateur Astronomers *‡
H. Cochran, 461 Collingwood St. (14). AT 2-3298

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W. Krumm, 10628 Larry Way, Cupertino.

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San Mateo Astronomical Society ‖
R. Johnston, 806 Fiesta Dr. FI 3-7783

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Santa Barbara Star Cluster ‡
Capt. C. Adair, 607 Miramonte Dr. WO 2-1717

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R. Young, Box 531. OX 3-0320

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Yucaipa Amateur Astronomers *
C. Tapley, 33089 Yucaipa Blvd. PY 7-2632

COLORADO

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HAWAII

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E. G. Linsley, B. P. Bishop Museum (17). 85951

IDAHO

IDAHO FALLS
Idaho Falls Astronomical Society *
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TWIN FALLS
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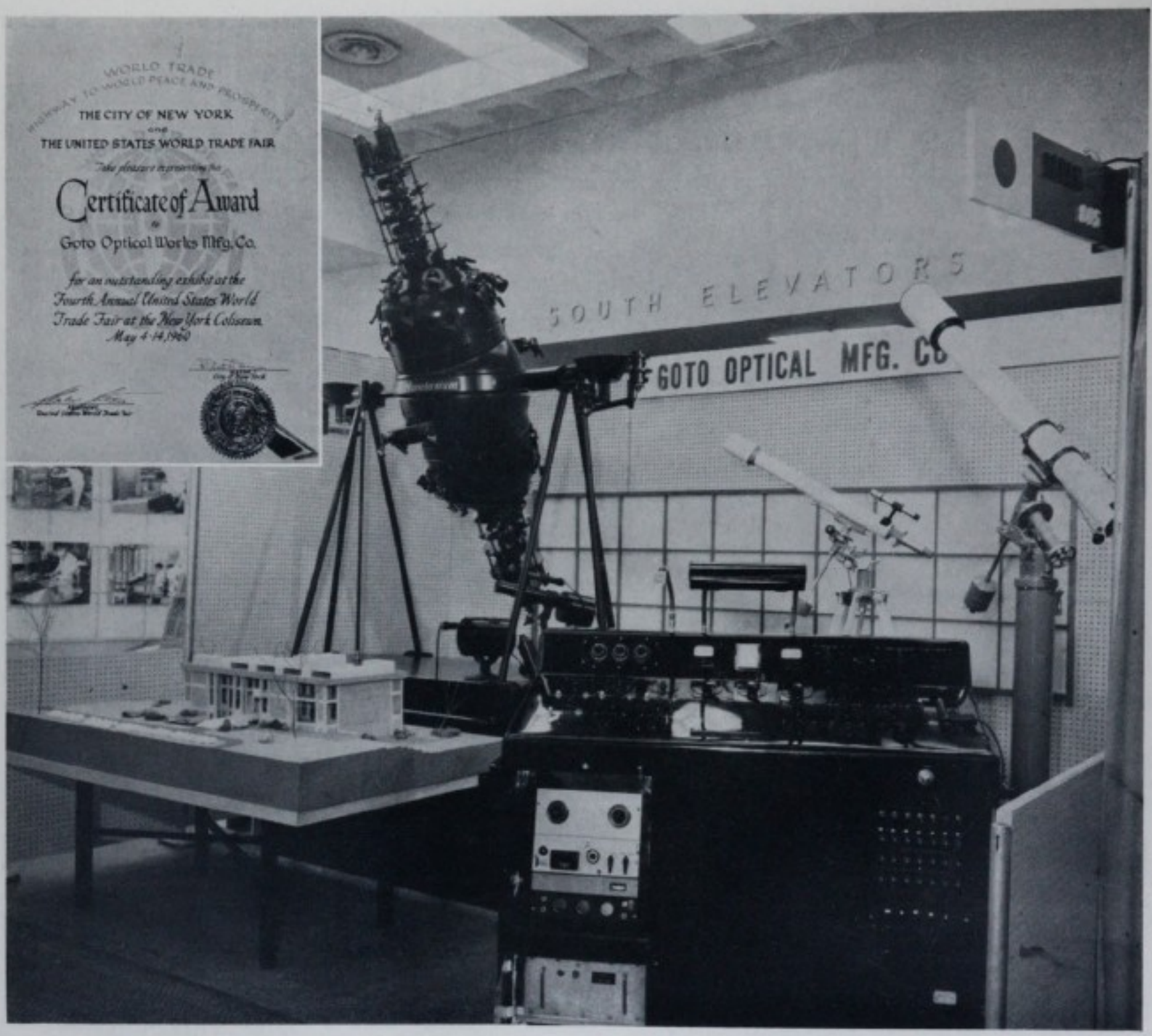

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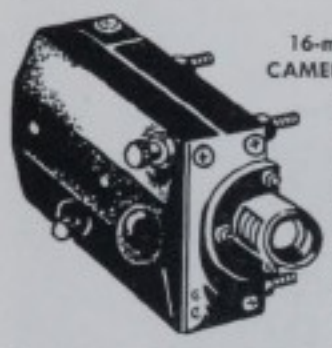

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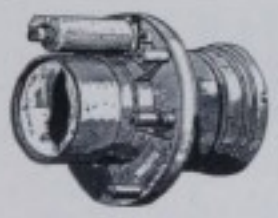

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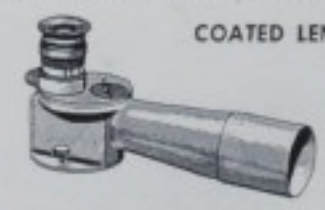

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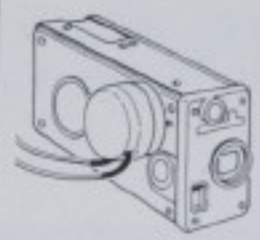

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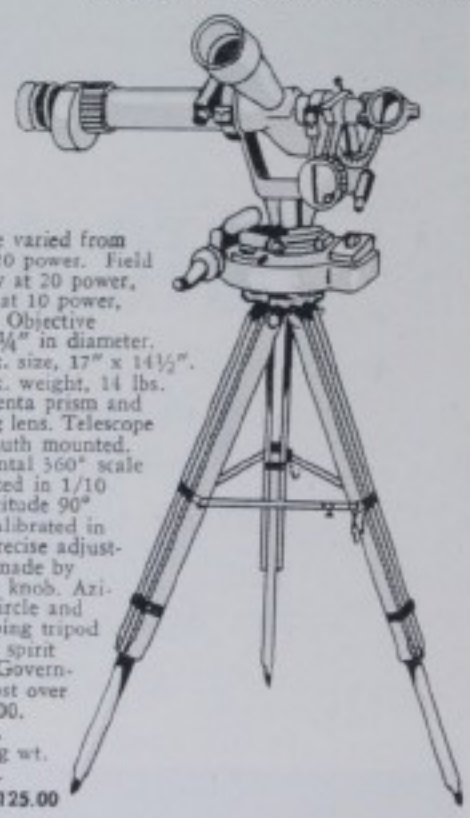

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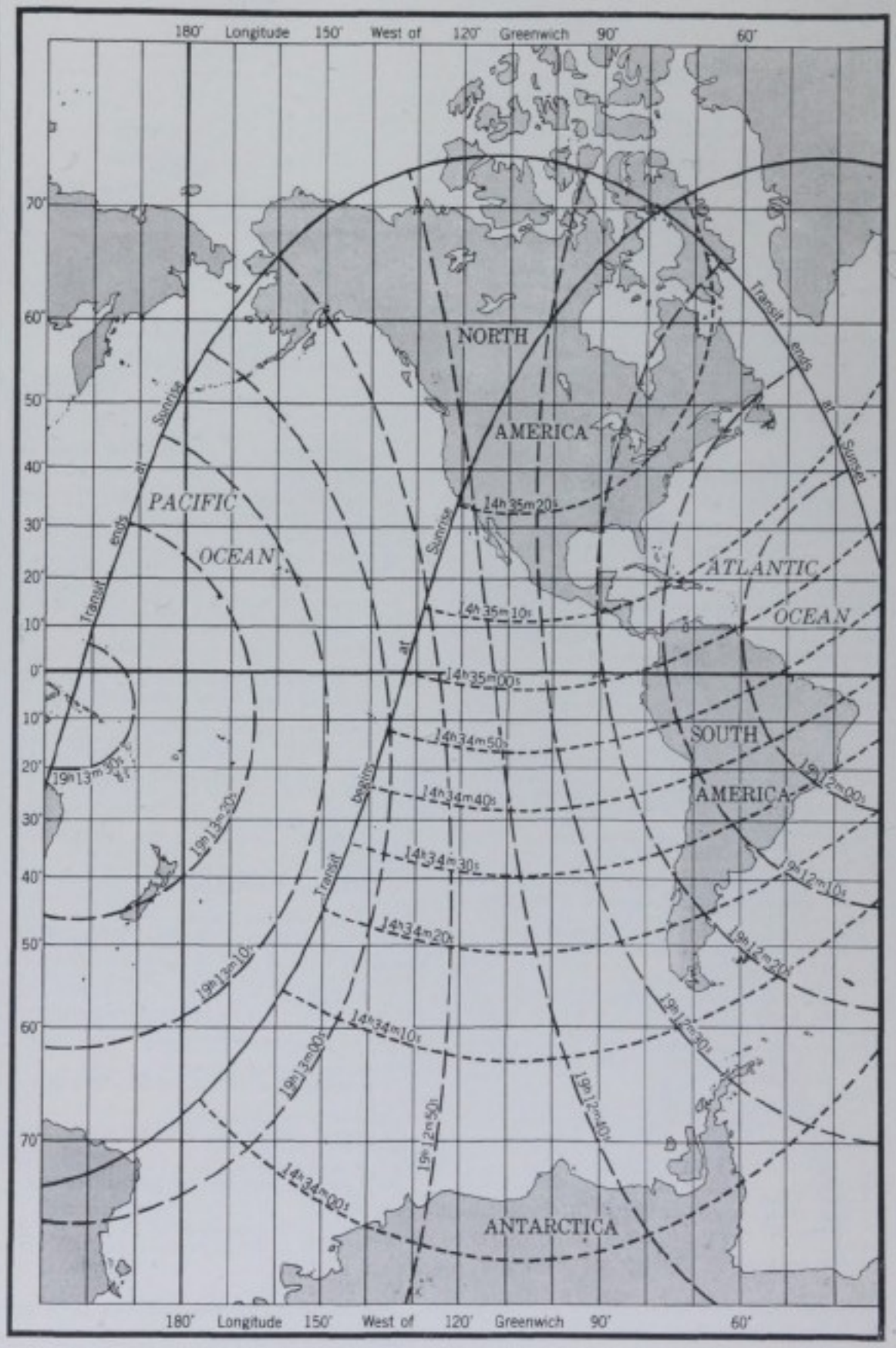
OBSERVER'S PAGE

Universal time (UT) is used unless otherwise noted.

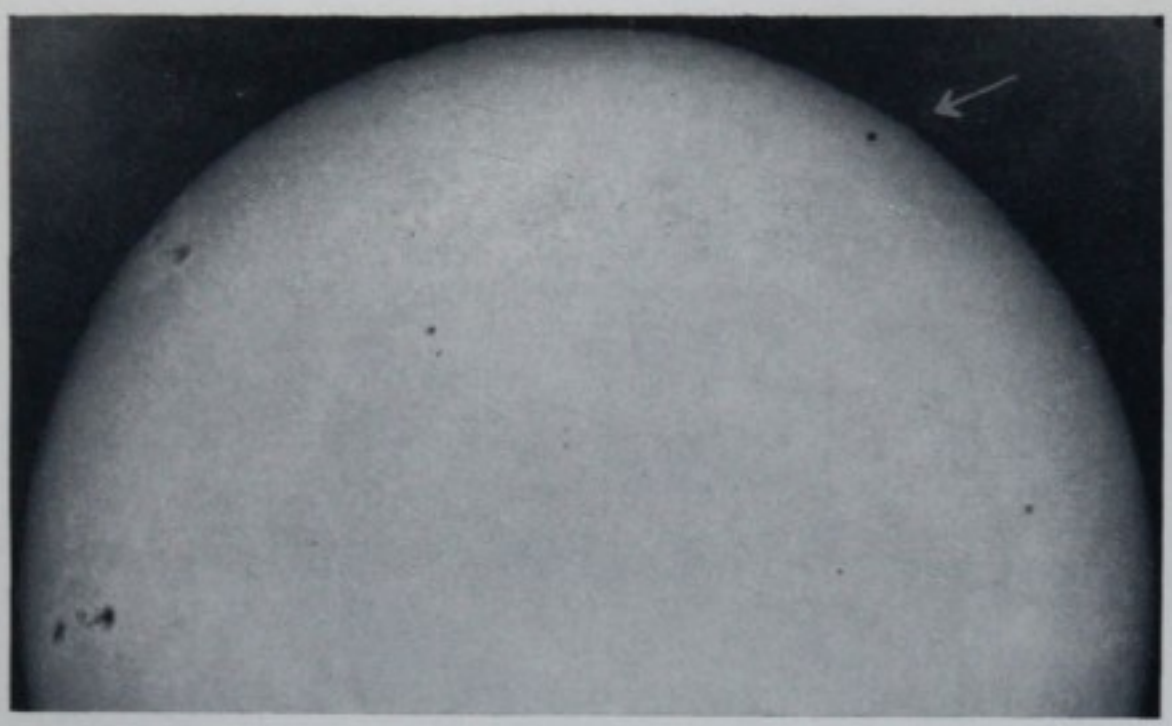
November Transit of Mercury

OBSERVERS throughout most of the Western Hemisphere will be able to view a transit of Mercury on the morning of Monday, November 7th, as shown by the accompanying map. The disk of the planet will be visible as a tiny black spot crossing the sun, even in small telescopes. Three years have elapsed since the previous transit, on May 5, 1957, and it will be 10 years until the next, on May 9, 1970.

This long event begins at 14:34 Universal time and ends at 19:12. These times correspond to 9:34 a.m. and 2:12 p.m. Eastern standard time, 8:34 and 1:12 CST, 7:34 and 12:12 MST, and 6:34 and 11:12 PST. There is a slight variation in time across the country; the figures



This chart of the November 7th transit of Mercury may be used to predict Universal times of the beginning and end of the phenomenon for observers in North and South America. The times of first contact are given by the lines of short dashes, fourth-contact times by the lines of longer dashes. No transit will be visible outside the area covered by the network of curves. Reproduced from a more extended map in the "American Ephemeris."



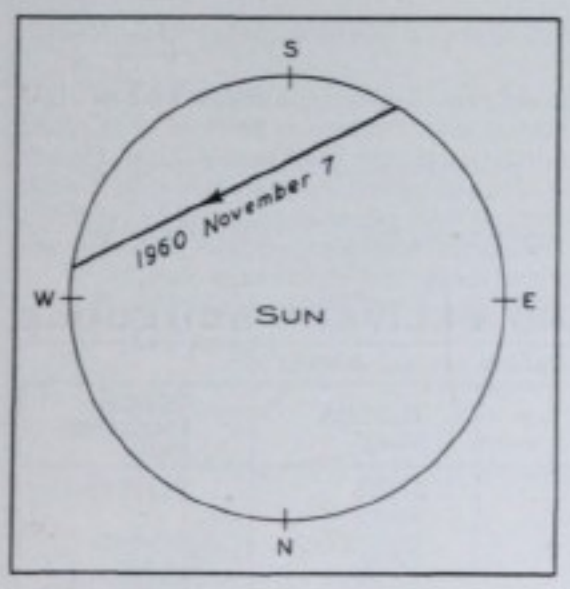
This photograph of the May 6, 1957, transit of Mercury was taken by Hans Arber in Manila, Republic of the Philippines. The planet (indicated by the arrow) is on the northern part of the sun's disk. Notice how much darker Mercury appears than sunspots of approximately the same size.

given here are good to within a minute or two.

For watchers in the Pacific Northwest and most of the West Coast, the transit begins before sunrise – when the sun comes up, Mercury will already be visible on its disk. All others in the continental United States will be able to see the planet begin to encroach on the disk, two minutes being required for Mercury to pass from being externally tangent to the sun (first contact) to being internally tangent (second contact). There is a similar interval between third and fourth contacts, when Mercury leaves the sun.

Great care should be exercised in protecting the eye from damage by sunlight while viewing this spectacle. Use the same precautions as in viewing sunspots, such as a very dense neutral filter and a Herschel wedge. Diaphragming the telescope to a 2- or 3-inch aperture will help cut down the amount of sunlight. A very good method is to project the image of the sun on a screen behind the eyepiece. This also enables a number of people to watch the transit simultaneously.

Probably the most useful observations to be made at a transit of Mercury are accurate timings of the contacts. A clock or watch used for this purpose must be compared with WWV or CHU radio time signals, so that its correction is known



The apparent path of Mercury across the sun's disk is shown here. First contact occurs at position angle 148 degrees, last contact at 262 degrees. Position angle is measured eastward from the north point.

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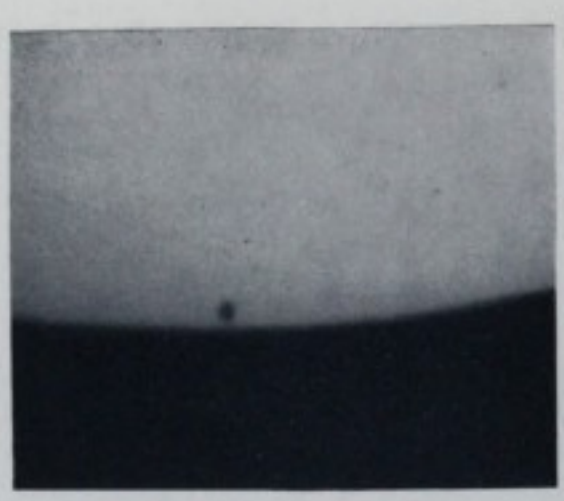
to within one second. A method for recording the observations and time signals with a tape recorder was described in the October, 1956, issue, page 542 (out of print).

The frequencies on which WWV time signals are broadcast are 2.5, 5, 10, 15, 20, and 25 megacycles per second in the shortwave band. CHU signals are broadcast from Ottawa and are easily received in the northeastern part of the United States. The frequencies are 3.33, 7.335, and 14.67 megacycles.

Useful timings of contact I are not possible, as this stage is already past when the planet first becomes visible as a notch in the solar limb. For contact II, the time to record is the breaking of the "black drop" that apparently connects the disk of Mercury with the solar edge. If no black drop is seen, the observer should note the instant when Mercury appears to be internally tangent to the sun's disk.

At contact III, the events of II occur in reverse order. The phase to time is the breaking of the thread of light separating Mercury's black disk from the sun's edge. Contact IV is final disappearance of the notch in the solar limb, as Mercury moves off the sun.

SKY AND TELESCOPE will be pleased to receive reports of careful observations of contact times for discussion and publication. Each time should be given to the nearest second or closer, with full details of how the observation was made. The observer's latitude and longitude should be stated, to the nearest minute of arc, as this information is needed for the reductions.



J. M. Spooner's photograph of the 1953 transit shows Mercury just before it passed off the sun's northern limb.

Transits of Mercury are a favorite subject for amateur photography. The event is photographed in exactly the same manner as sunspots, though processing for slightly more contrast may be desirable. It is a good idea to set up equipment on days before the transit and perfect filming and timing technique. A small telescope (say a 2½-inch refractor or a 4-inch reflector), used with eyepiece projection, will provide sufficient scale to record the phenomenon.

SUMMER AURORAS

ALTHOUGH the peak of the 11-year sunspot cycle was passed in the beginning of 1958, solar activity still remains at a high level, resulting in many fine auroral displays last summer.

During the second half of June, northern lights were seen on several nights. The most striking of these was on June 24th. At Madison, Wisconsin, G. Rippen recorded an unusually rapid five-minute alternation between quiet and rayed arcs.

The major auroral storm of July 15th was reported by many readers from Maine to Wisconsin, and as far south as New Jersey. C. W. Walker, at Sebec Lake, Maine, noted a bright pulsating corona near the zenith at 8:30 p.m. Eastern standard time, while curtains and rays reached nearly to the southern horizon. On the 19th, moderate auroral activity was noticed by several observers during the occultation of Aldebaran, and other displays were seen during the last two nights of the month.

On August 16th, another great aurora took place. M. Hall, watching at Richville, New York, saw most of the sky, nearly to Jupiter and Saturn in the south, covered by brilliant green rays that converged on a point near Beta Cygni, at 8:45 p.m. EST. Other reports of the same display were received from Wisconsin, Illinois, and Rhode Island, indicating widespread auroral activity.

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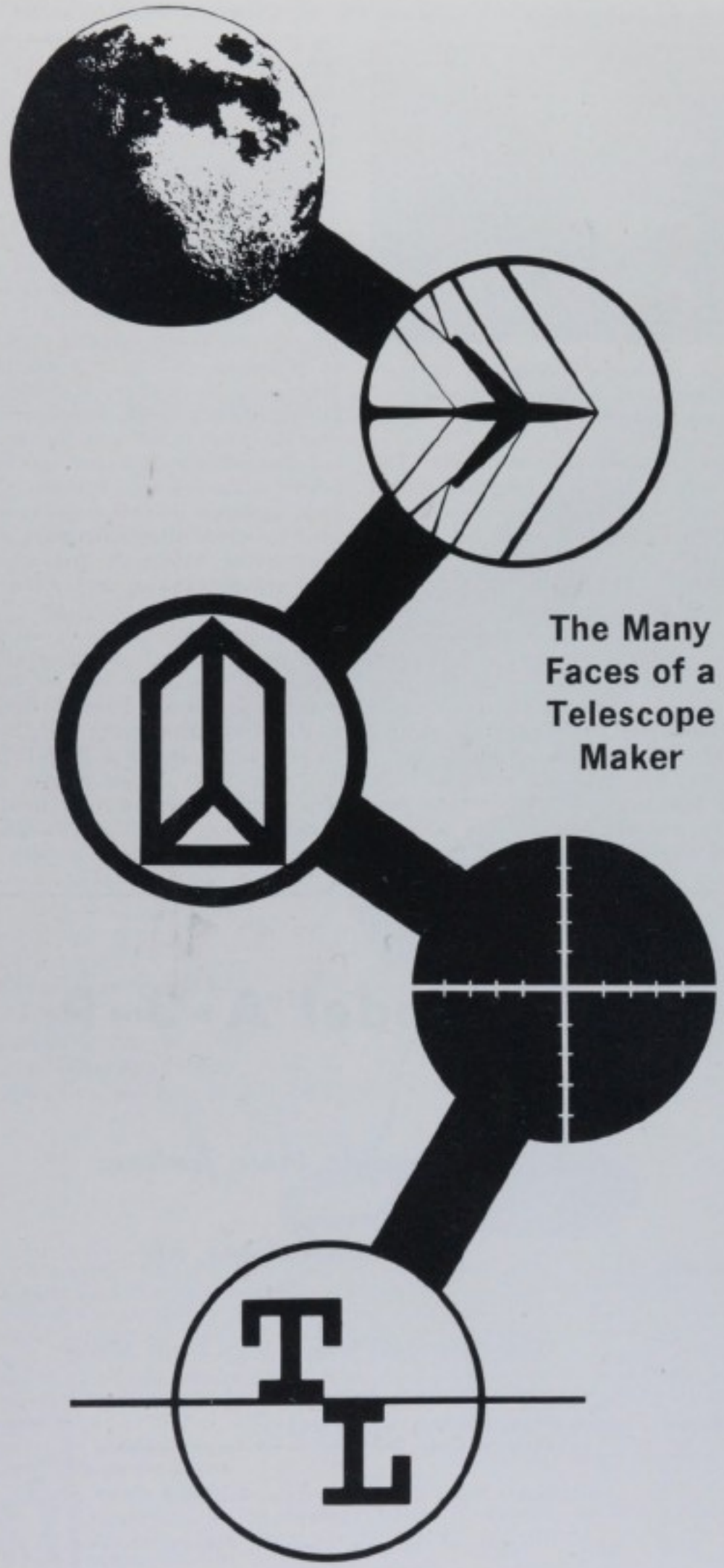

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LOCATED in the northeastern limb region of the moon, not far from the eastern edge of Sinus Roris, is the peculiar formation Rümker. It is not a crater but a low plateau, about 30 miles in diameter, rising some 2,500 feet above the surrounding plain, according to J. F. J. Schmidt.

Rümker is so near the limb that our line of sight to it is inclined 66 degrees to the vertical through this plateau, under average conditions of libration. Hence, while the true outline is nearly circular, we see it foreshortened into an ellipse, whose shape may be greatly modified by libratory changes.

Surrounded by a comparatively barren level region, Rümker is easily observable for only a short time each month. When the sun rises on it, about 2½ days before full moon, the formation is fairly conspicuous. It loses this prominence rapidly as the sun ascends, and by the time the solar altitude reaches 15 degrees or so, Rümker has become nearly invisible against its surroundings. This lack of contrast may be partly explained by the low elevation and gentle slopes, their shadows being short and vanishing soon after sunrise. In addition, Rümker may be largely composed of materials that are very similar in optical properties to those making up the extensive level tract around it.

Until quite recently, relatively little attention had been paid to Rümker by selenographers. It was inadequately or erroneously charted by Schmidt, T. G. Elger, W. Goodacre, and H. P. Wilkins. A fine photograph of this formation and its surroundings, taken with the 82-inch McDonald reflector, was published by

Compare the Herring drawing of Rümker with this photograph by Gerard P. Kuiper, taken with the 82-inch telescope of McDonald Observatory. The sun had just risen over this remarkable mass of low hills, whose flanks were still shadowed. Reproduced from "Vistas in Astronautics."

This sketch of Rümker was made by Alika K. Herring on March 11, 1960, at 4:45 Universal time, with his 12½-inch reflector at 325x. The sun's colongitude was 69°.3, and the solar elevation over Rümker was 8°.6. South is upward, west to the left.

G. P. Kuiper last year, in *Vistas in Astronautics*, Vol. 2, page 297. Good drawings of Rümker are scarce. My representation of it, obtained under favorable conditions this March, should be useful to other observers who may wish to study this neglected formation.

In the drawing, the two largest craterlets are Rümker E and C, about four and three miles in diameter, respectively. The most noteworthy features in the plateau itself are the large, squarish enclosure that opens toward the northwest, the numerous rounded domelike hills that give the main formation a decidedly lumpy appearance, and several small craterlets less than a mile in diameter.

The true nature of Rümker has not been generally recognized. My drawing indicates that it is a large laccolithic uplift, or in other words a giant dome made up of smaller ones. Kuiper also states that it "may probably be regarded as a compound lava dome." Rümker must be one of the largest examples of its kind on the lunar surface.

ALIKA K. HERRING
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Each year the Indiana Astronomical Society gives a star party for the nearly 40 diabetic children who attend the James Whitcomb Riley camp, some 25 miles southwest of Indianapolis. Eight of our members made the trip on August 12th, bringing three reflectors and three refractors.

Every instrument was sighted on a different celestial object, and the children

Dr. D. R. Faun, president of the board of directors of the Indiana Astronomical Society, supervises camper Tom Borshoff's observations at the eyepiece of a 4-inch reflector.

moved from telescope to telescope to see each wonder. Before the observations, Walter Wilkens, society president, gave a discussion on what would be viewed.

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The globular cluster M72 is at the left in this Palomar 48-inch Schmidt telescope photograph. M73, an asterism of only four stars, is indicated by the two horizontal lines at the right. South is at the top in this reproduction, which has a field width of slightly over two degrees. M72 is located approximately 65,000 light-years away, and its stars are loosely packed in comparison with many globulars.

DEEP-SKY WONDERS

THE famous *New General Catalogue of Nebulae and Clusters of Stars* by J. L. E. Dreyer, usually called the NGC, is not a catalogue that he compiled from his own observations. Rather, its 7,840 objects were taken from dozens of lists published by other astronomers, and its main base was the catalogue of John Herschel.

Where data conflicted, Dreyer followed the most authoritative source. Many hundreds of errors in the older lists were discovered, though not all were caught. The NGC is still one of the basic sources of information for the deep-sky observer.*

One example of an object that should not have been included is M73 — No. 6994 in the NGC. Older charts denote this as a cluster, but modern ones do not. Actually, it is merely four faint stars that can hardly be considered a cluster, and it is surprising that Messier even listed it. In truth, it is another "missing" Messier object (see page 196 of this issue). The little group of four stars is centered on right ascension $20^h\ 56^m.4$, declination $-12°\ 50'$ (1950).

The picture reproduced here shows, in addition to M73, the relatively bright globular cluster M72 (NGC 6981), located at $20^h\ 50^m.7$, $-12°\ 44'$, about $1\frac{1}{3}$ degrees away. It was found by P. Méchain, who was responsible for the discovery of many of the objects in Messier's catalogue. This 10th-magnitude cluster is only 5.1 minutes of arc in diameter, but it stands out in southwestern Aquarius. A 13-inch telescope in Milwaukee, Wisconsin, shows M72 as a respectable object, and averted vision gives some resolution at the cluster's edge. A 6-inch rich-field instrument at Brownsville, Texas, makes it unmistakably globular, and seemingly brighter than 10th magnitude.

WALTER SCOTT HOUSTON

*ED. NOTE: The NGC is available in reprint form from the Royal Astronomical Society, Burlington House, London W. 1, England, at £3 10s. This same volume also contains the two *Index Catalogues* issued in 1895 and 1908 to supplement the original NGC of 1888.

SUNSPOT NUMBERS

The following provisional mean relative sunspot numbers for August were obtained by Dr. M. Waldmeier, director of Zurich Observatory, from observations there and at its stations at Locarno and Arosa.

August 1, 63; **2**, 53; **3**, 31; **4**, 32; **5**, 25; **6**, 24; **7**, 57; **8**, 57; **9**, 76; **10**, 94; **11**, 156; **12**, 207; **13**, 235; **14**, 236; **15**, 252; **16**, 244; **17**, 232; **18**, 225; **19**, 217; **20**, 202; **21**, 177; **22**, 168; **23**, 130; **24**, 113; **25**, 131; **26**, 140; **27**, 109; **28**, 98; **29**, 97; **30**, 96; **31**, 84. Mean for August, 131.0.

ANOTHER BRIGHT VARIABLE

A new variable star in Draco, bright enough to be easily observed with binoculars, has been reported by W. Strohmeier of Remeis Observatory, Bamberg, West Germany. This object is HD 140,117, a $6\frac{1}{2}$-magnitude star of spectral type *K*0. Its 1950 co-ordinates are $15^h\ 38^m.1$, $+58°\ 05'$ — not far from Iota Draconis. Dr. Strohmeier finds from patrol photographs that it is an irregular variable, with fluctuations ranging up to 0.8 magnitude.

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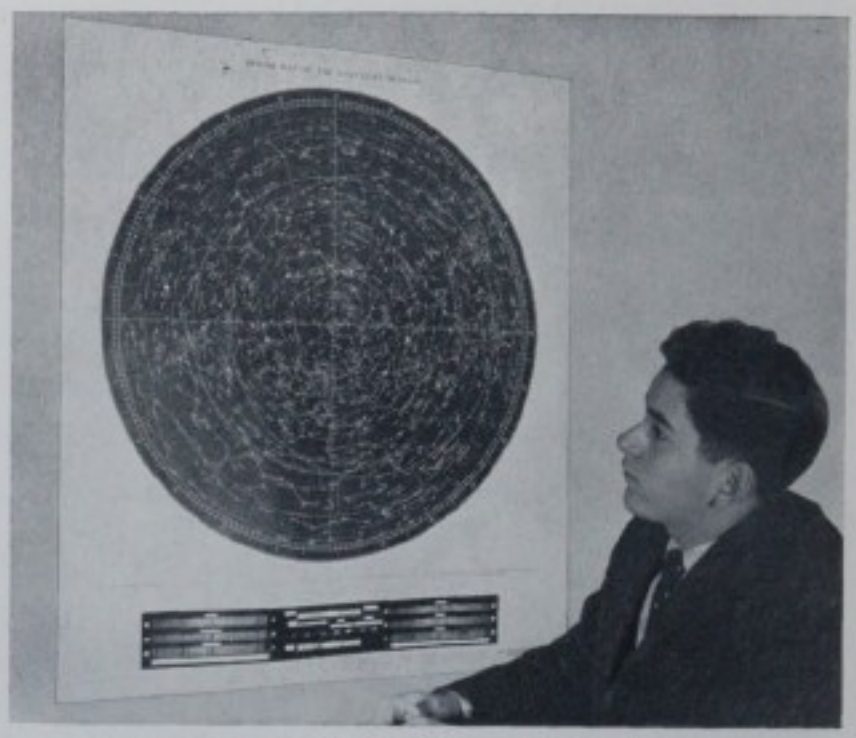

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BOOKS AND THE SKY

A BEGINNER'S GUIDE TO THE STARS

R. Newton Mayall and **Margaret W. Mayall.** G. P. Putnam's Sons, New York, 1960. 184 pages. $2.50.

TODAY amateur astronomy is experiencing a rapid growth, and many persons are getting to know the deep pleasure that comes from an acquaintance with the starry skies. Newly interested observers, however, have sometimes met difficulties because of the lack of a suitable introductory handbook. Several authors and publishers have attempted to fill this gap, but in some cases their work has suffered from hasty preparation, or has discouraged the beginner by offering material on too juvenile a level.

This new field guide overcomes many of these problems. The Mayalls assume that the reader is intelligent but unfamiliar with astronomy. The pleasant result is an informative book, attractive to adults and young people alike. It contains enough material to get the beginning amateur well under way, without burdening him with lengthy detail.

Following a brief introduction to the constellations and a little of their traditional lore, some basic notions useful to amateurs are presented in Chapter 2. Here such topics as stellar magnitudes, motions in the sky, the use of star charts, and color in the heavens, are described. The authors are careful to define all terms used and to avoid the standard textbook style of so-called introductory books.

Throughout, the emphasis is on naked-eye sky objects and on those visible in binoculars. In addition to stars and constellations, the amateur is introduced to meteor showers, star clusters, lunar surface features, and more. Comets and artificial satellites are specifically mentioned as interesting to the observer who has little or no equipment.

Unfortunately, very little information is given about satellite observation, and the novice will be left as completely in the dark as before. The Mayalls point out that the passages of the various satellites cannot be predicted far in advance, merely saying, " . . . we must rely on publicized reports to know when and where to look. . . ." It would have been helpful to the beginning observer if a few pointers had been given on how to distinguish an artificial satellite from such things as meteors and high-flying airplanes.

Chapter 4 extends the authors' discussions to slightly more difficult subjects of observation, such as variable and double stars and occultations.

Binoculars and their use are presented next. Although the Mayalls suggest 8 x 50 binoculars, the proven and more popular 7 x 50 size is much to be preferred in astronomy. Even so, many people cannot hold such instruments steady enough to allow successful observing. A considerable amount of weight can be saved by employing a 7 x 50 monocular. The slight loss in power is more than offset by the increase in steadiness and ease of handling. The monocular costs less, too.

In Chapter 6, there is an account of what can be seen on the moon's disk with hand-held instruments. Users of the lunar chart on page 53 will want to make the following corrections to the key facing it: Craters 1, 14, and 17 are Aliacensis, Fracastorius, and Albategnius, respectively, while features K and L are both Oceanus Procellarum.

Following a useful treatment on identifying the planets, there is a good discussion on using sky maps, together with a list of constellations, and several general charts. As is common in abridged maps, not every star brighter than the general magnitude limit is included, while other, fainter stars are added to complete constellation figures. This is often a source of difficulty to someone unfamiliar with the stars, when he attempts to compare the charts with the sky. Mention should have been made here of the use of a red light for reading the maps at night. A flashlight capped with several layers of red cellophane is excellent.

The heart of the book is Chapter 9,

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These notes are brief and clear. Occasional misstatements are evidently the result of copying from older handbooks. For example, the Bielid meteor shower mentioned on page 74 has shown very little activity for many years. On page 128, the double star Gamma Leonis should probably have been omitted, as its components are separated by only four seconds of arc — much too close for binoculars to split. The incorrect statement (page 146) that Algol remains at minimum light for 20 minutes is surprising to find in a book whose authors include a variable star specialist.

The volume concludes with odds and ends of useful information. Approximate planet positions through 1965, hints on solar observing, the Greek alphabet, and similar items are given.

Although still leaving something to be desired, *A Beginner's Guide to the Skies* is probably the best handbook now available for a newcomer to amateur astronomy. It should serve the same purpose as the older book that it so closely resembles, W. T. Olcott's *Field Book of the Stars*.

R. N. W.

ISAAC NEWTON

Beulah Tannenbaum and **Myra Stillman.** McGraw-Hill Book Co., New York, 1959. 128 pages. $3.00.

THE GROWING TIDE of science in American life has caused a fast-increasing number of brightly jacketed books intended to introduce scientific subjects to younger readers. Many of these are error-filled attempts to exploit popular interest. Selecting the best can be a difficult problem for parent, teacher, or librarian.

Isaac Newton is easily among the first rank in recent science books for those of junior high or high school age. It is a readable, well-informed life of England's greatest man of science, whose discoveries in astronomy, physics, and mathematics have so deeply influenced the world in which we live. To him we largely owe the far-reaching idea of a universe governed by simple natural laws, whose language is mathematics.

Not only Newton's influence but his versatility make him especially suitable as the central theme of a book about science. The authors have used this opportunity effectively. Thus, their account of Newton's discoveries in optics leads to brief but clear discussions of telescope construction and of modern ideas about the nature of light.

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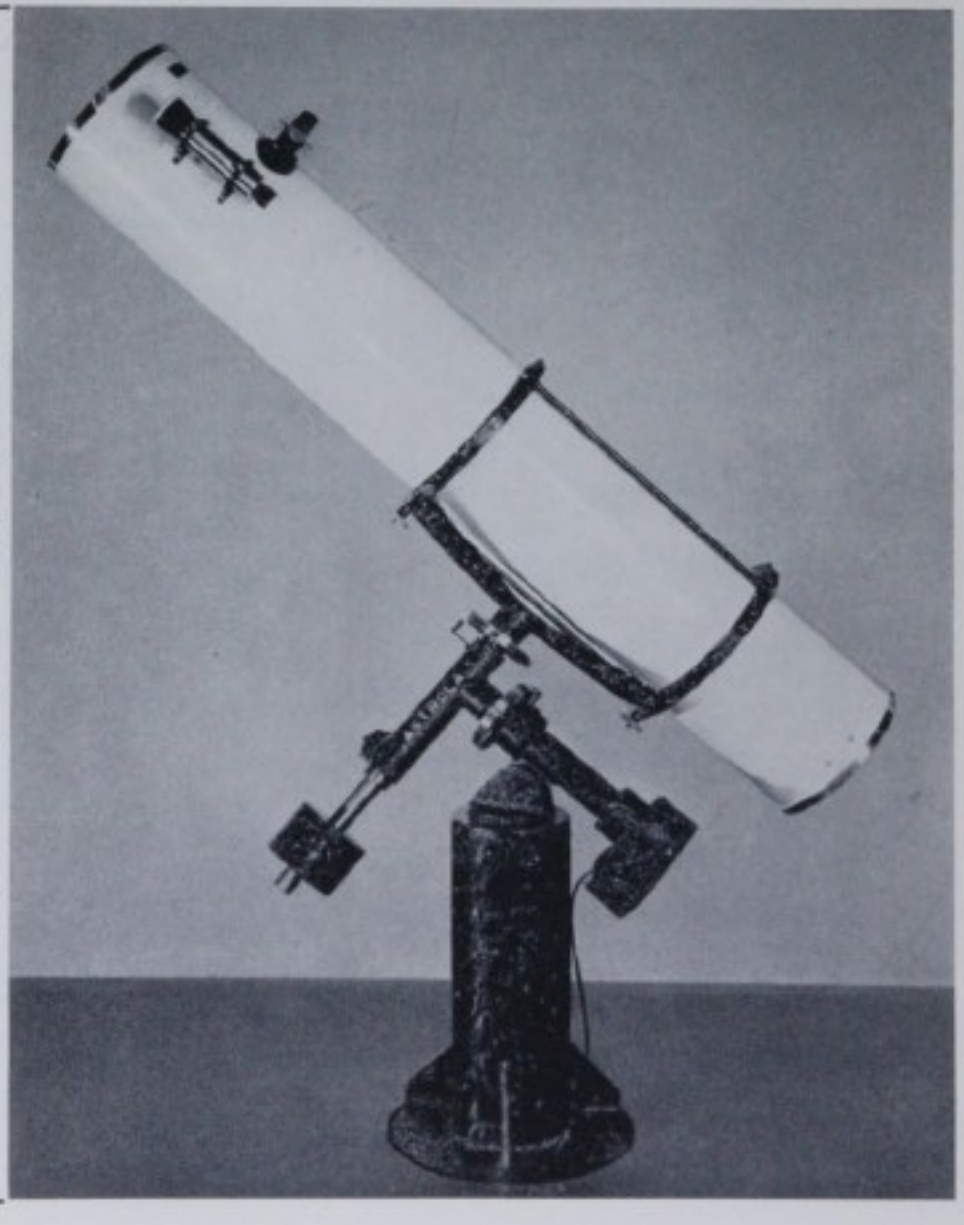

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among his contemporaries. The reader meets Robert Hooke, Edmond Halley, and other leading figures of the Royal Society, and tastes the flavor of the age in which they lived. The historical context is recreated with much skill. It is all too rarely that books for younger readers capture anything of scientific humanism.

Despite the solid content of *Isaac Newton*, it is a simply and clearly written book, with a flow of anecdote and interesting personal detail that carries the reader along. There are no blind alleys into obscurities, nor, on the other hand, is there "talking down."

So much well-digested biographical information is attractively presented that this little book is worth the attention of those of any age who want to know something about Newton.

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MOON MAPS

H. P. Wilkins. Macmillan Co., New York, 1959. 65 pages. $6.00, spiral bound.

THIS is a virtually unaltered republication, enlarged to a scale of 40 inches to the moon's diameter, of the lunar map in H. P. Wilkins and P. Moore's *The Moon* (1955). It consists of 25 charts which together represent the lunar disk at mean libration and contain about 90,000 formations. The 26th chart is essentially identical to the detail map of Ptolemaeus on page 61 of the 1955 book, while the 27th identifies some features on the far side of the moon.

The accompanying text consists almost entirely of a list of some 700 named formations, with an indication of the charts on which they appear, and a sentence or two of description.

Unfortunately, the scientific usefulness of this lunar atlas is not commensurate with the enormous labor its author devoted to charting our satellite. The reasons for this have been given by K. W. Abineri and D. W. G. Arthur in the *Journal* of the British Astronomical Association, *66*, 177, 1956, in their searching review of *The Moon*. Their criticisms apply equally to the present map.

In that 1956 review, attention was called to a number of specific errors, such as a gross misplacement of the crater Lippershey, and a nonexistent ring between Euctemon and Baillaud. These errors have not been corrected in the present version of the map, and there are some other indications that this never received the thoroughgoing revision it needed. It may not have been possible, for Wilkins was in poor health for some time before his death on January 23, 1960.

The amateur who already owns *The Moon* will probably find the purchase of *Moon Maps* unnecessary, since it is essentially a reprint. W. E. S.

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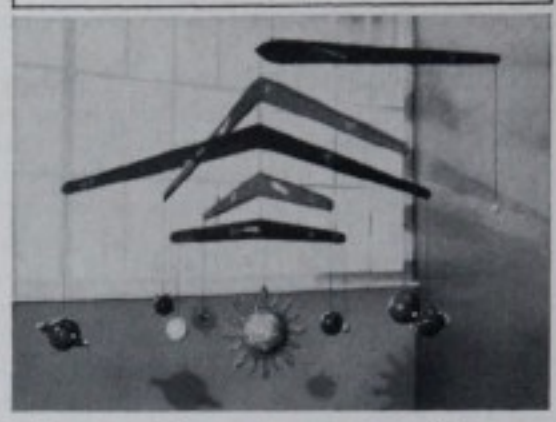

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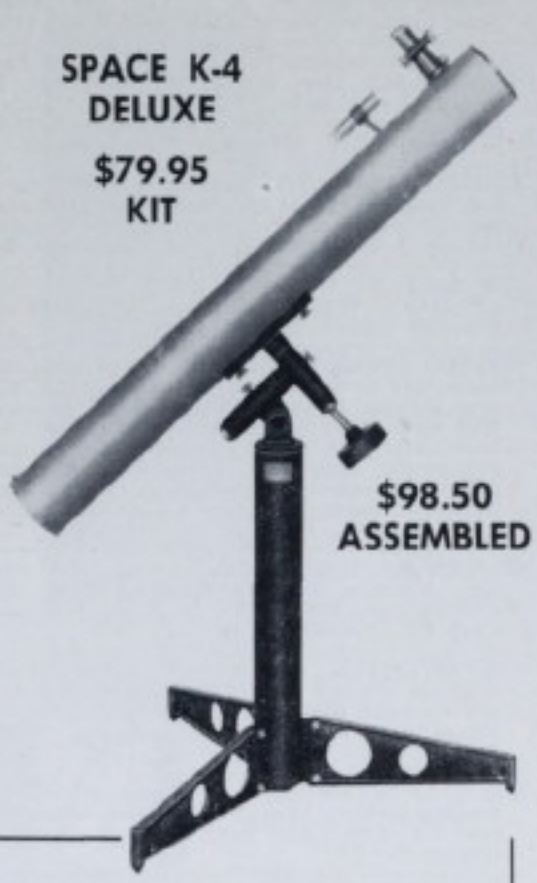

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NEW BOOKS RECEIVED

SCIENCE SURVEY — 1, *A. W. Haslett* and *John St. John*, editors, 1960, *Macmillan*. 360 pages. $5.75.

This collection of 26 popular yet authoritative summaries of recent scientific advances covers topics from nuclear reactions in stars to fish migration. Three chapters deal with earth sciences, five with space exploration.

A GUIDE TO THE STARS, *Patrick Moore*, 1960, *Norton*. 222 pages. $4.95.

A well-known British amateur describes the starry heavens, from constellations through double and variable stars, clusters and nebulae, and the Milky Way, to distant galaxies. The simply written text tells how the distances of stars and their other properties are found. Appendices list some interesting stars and telescopic objects for the beginner.

AVIONICS RESEARCH: SATELLITES AND PROBLEMS OF LONG RANGE DETECTION AND TRACKING, *E. V. D. Glazier, E. Rechtin*, and *J. Voge*, editors, 1960, *Pergamon*. 257 pages. $10.00.

Technical papers presented during an October, 1958, symposium at Copenhagen, Denmark, are now available in book form. They are of primary interest to specialists in the radar tracking of artificial satellites, and in the interpretation of radio observations of satellites.

THE FASCINATING WORLD OF ASTRONOMY, *Robert S. Richardson*, 1960, *McGraw-Hill*. 274 pages. $5.95.

This book answers in nontechnical language astronomical questions ranging from "How do you become an astronomer?" to "Why are cluster variables important?" Many photographs and drawings complement the text, which is mostly about solar system objects. The author is associate director of the Griffith Observatory and Planetarium.

SCIENCE, *J. Bronowski*, editor, 1960, *Doubleday*. 367 pages. $9.95.

This profusely illustrated book is a broad popular review of chemistry, physics, and astronomy. The nearly 80 pages on astronomical topics are by Patrick Moore. The encyclopedic presentation is augmented with a glossary of a thousand scientific terms.

THE NATURE OF THE UNIVERSE, *Fred Hoyle*, 1960, *Harper*. 141 pages. $3.00.

In this revised and up-dated version of a book first published in 1950, a leading British cosmologist tells in nontechnical language of the past, present, and future of the astronomical universe.

THE RADIO NOISE SPECTRUM, *Donald H. Menzel*, editor, 1960, *Harvard University Press*. 183 pages. $7.50.

Thirteen papers presented at a conference on radio noise, held at Harvard Observatory in 1958, cover aspects of radio astronomy from man-made radio noise to electromagnetic emission from meteors, noise of planetary origin, and interstellar hydrogen.

ADVANCES IN SPACE SCIENCE, Vol. II, *Frederick I. Ordway, III*, editor, 1960, *Academic Press*. 450 pages. $13.00.

Space physics, satellite and space-vehicle tracking, materials, electrical propulsion systems, and attitude control are the topics covered in this volume, one of a series on space technology.

LA RADIOASTRONOMIE, *A. Boischot*, 1960, *Masson et Cie.*, 120 Boulevard Saint Germain, Paris 6, France. 125 pages. 13 NF, paper bound.

Findings from radio observations of the sun, moon, planets, the Milky Way, and discrete sources, are surveyed in this volume for the general reader with some scientific background. The text is in French.

PHYSICS OF THE UPPER ATMOSPHERE, *J. A. Ratcliffe*, editor, 1960, *Academic Press*. 586 pages. $14.50.

Detailed authoritative accounts of all branches of the study of the atmosphere above 60 kilometers compose this book. There are chapters on the upper atmosphere (M. Nicolet), rocket and satellite studies (H. E. Newell, Jr.), the aurora (D. R. Bates and H. G. Booker), and a synopsis of advances made during the International Geophysical Year. Extensive bibliographies are included.

IMAGES DU CIEL, *J. Gauzit*, 1960, *Dunod*, 92 Rue Bonaparte, Paris 6, France. 66 pages and 89 plates. 18.50 NF, paper bound.

Nearly 100 large photographs, mostly taken with the world's largest telescopes, present showpieces of the sky, from the moon and planets out to distant clusters of galaxies. This collection is preceded by a popular summary of modern astronomy, in French.

ORBIT THEORY, *Garrett Birkhoff* and *R. E. Langer*, editors, 1959, *American Mathematical Society*, 190 Hope St., Providence 6, R. I. 195 pages. $7.20.

Ten recent contributions to celestial mechanics deal with the motions of charged particles in the earth's vicinity, artificial satellite problems, and planetary motion. This publication is Vol. IX of *Proceedings of Symposia in Applied Mathematics*.

A STRUCTURE OF SCIENCE, *Joseph H. Simons*, 1960, *Philosophical Library*. 269 pages. $4.75.

A professor of physical chemistry describes the nature of science and of scientific ideas, without using mathematics or abstruse concepts.

SPACE BIOLOGY, *James Stephen Hanrahan* and *David Bushnell*, 1960, *Basic Books*. 263 pages. $6.00.

Two historians of science report the findings so far on how the human body will fare in space travel. The cultural impact of astronautics is critically analyzed.

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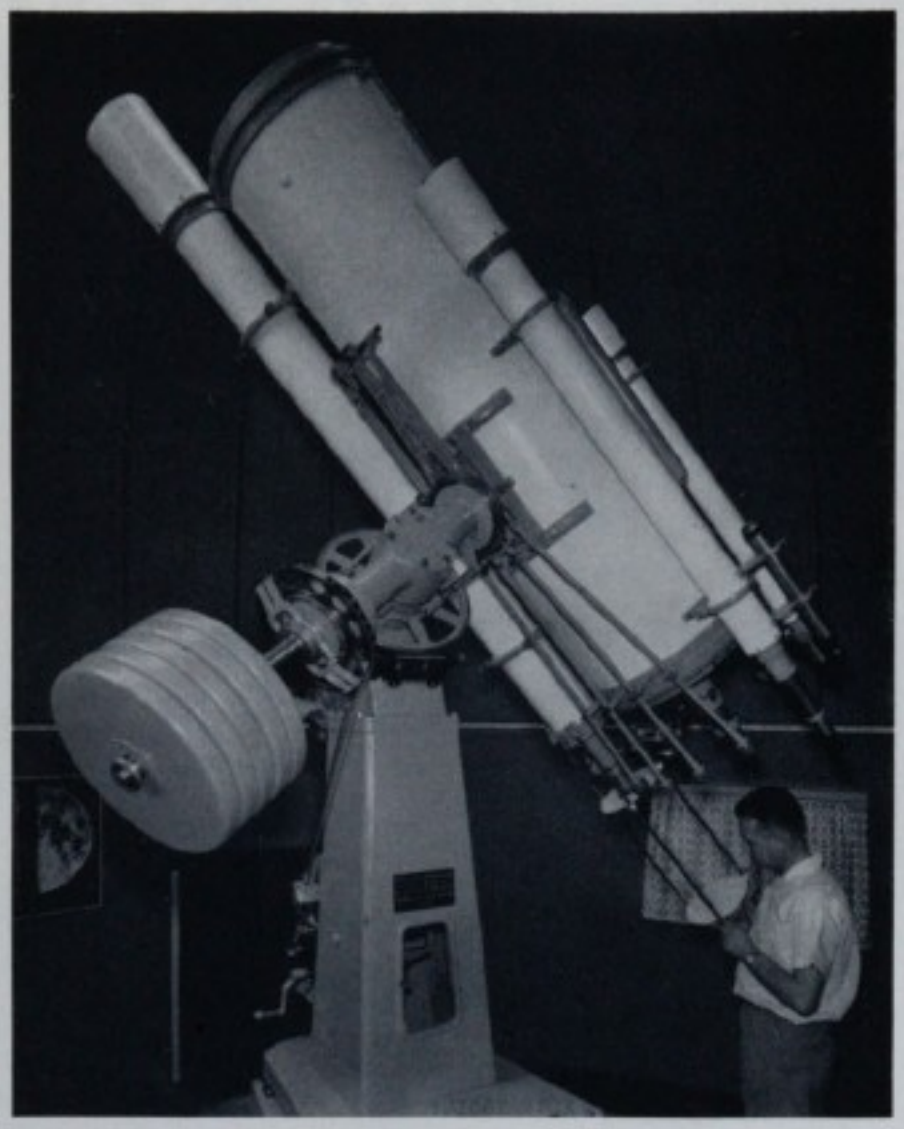
FOR SALE: *Proceedings* of the Western Amateur Astronomers' 1960 convention. $1.50 per copy. Group photograph, $1.00. Walter J. Krumm, 10628 Larry Way, Cupertino, Calif.



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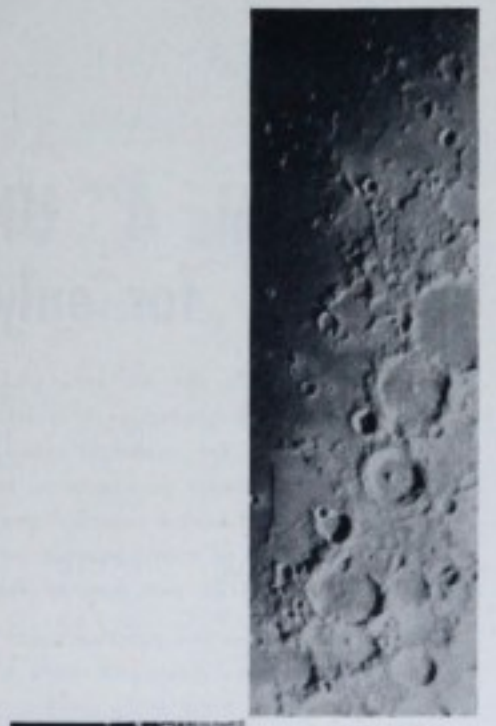

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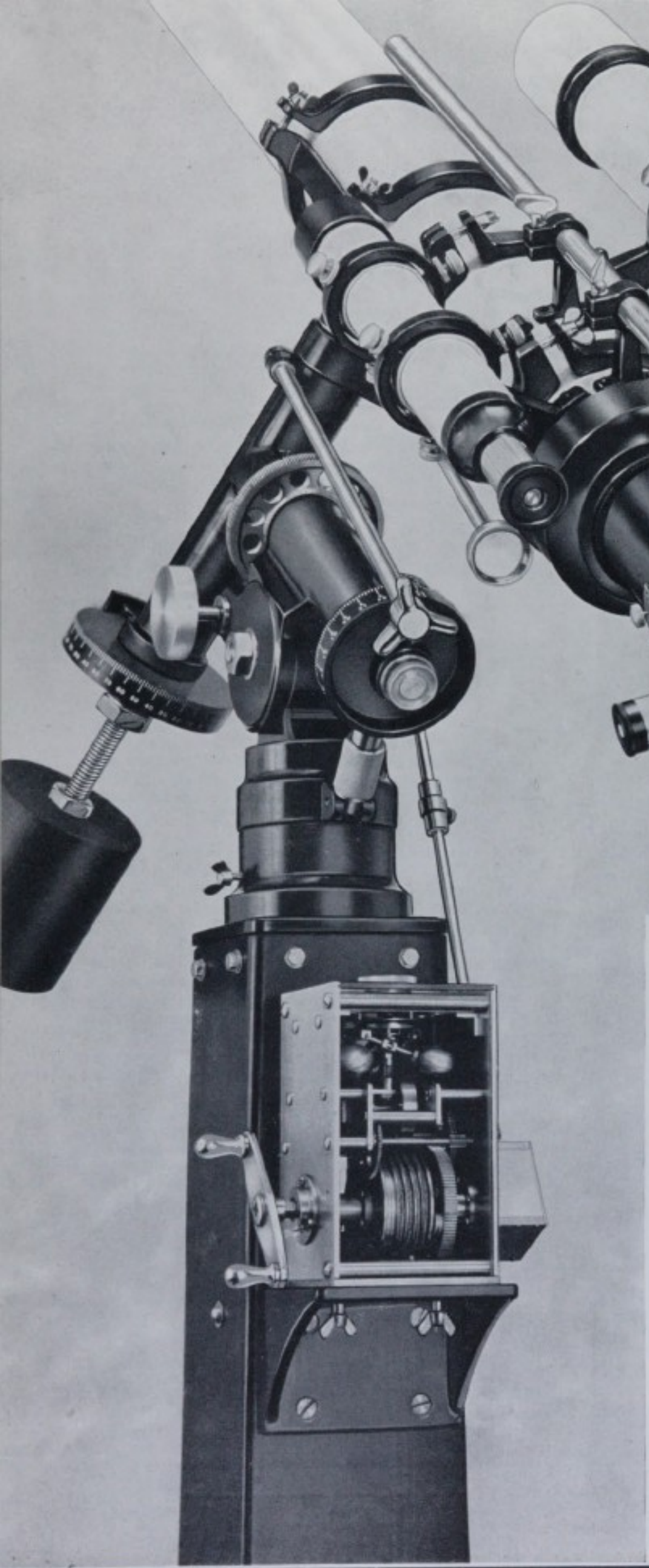

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There are other UNITRON 4" models for as little as $465 complete ($46.50 down) and other UNITRON Refractors for as low as $75 ($7.50 down). All may be purchased using our Easy Payment Plan. Whichever model you choose, you are assured of obtaining the finest instrument in its class. After all, it is a UNITRON.

See the back cover.

UNITRON

INSTRUMENT DIVISION of UNITED SCIENTIFIC CO.
204-206 MILK STREET BOSTON 9, MASSACHUSETTS

New "Achromatic Amplifier" now free with each UNITRON

UNITRON's new "Achromatic Amplifier" is a two-element, Barlow-type, negative amplifying lens designed especially for UNITRON Refractors. When used with a UNITRON eyepiece, it **doubles** the normal magnification of the telescope. Here is an ideal way to increase the usefulness of each eyepiece and to obtain the high magnifications that you have always wanted for planetary and lunar observations. The magnification factor of 2x has been selected as the most useful for general amateur observing under a wide variety of atmospheric conditions.

Two types of mounting cells are offered: one to fit the UNIHEX Rotary Eyepiece Selector and one for the UNITRON Star Diagonal. Either type can be inserted or removed in a jiffy. There are no cumbersome tubes to attach, nor ever any need to adjust the focus of the "Achromatic Amplifier." You merely use your regular standard or accessory UNITRON eyepieces in the UNIHEX or star diagonal in the customary manner. The unique optical design matches the UNITRON objectives and eyepieces to insure sharp definition without loss of resolution.

This useful and valuable accessory **is now included as standard equipment** with all UNITRON Refractors at **no additional cost** . . . another of the many reasons why the telescope you choose should be a UNITRON.

The new "Achromatic Amplifier" will be offered as a separate accessory to those who already own UNITRONS. Further details will be announced in our November advertisement.

MANY Models To Choose From!

2" SATELLITE ($7.50 Down) 6x, diagonal eyepiece, altazimuth mount with circles, stand — **$75**

1.6" ALTAZIMUTH ($7.50 Down) with eyepieces for 78x, 56x, 39x — **$75**

2.4" ALTAZIMUTH ($12.50 Down) with eyepieces for 100x, 72x, 50x, 35x — **$125**

2.4" EQUATORIAL ($22.50 Down) with eyepieces for 129x, 100x, 72x, 50x, 35x — **$225**

3" ALTAZIMUTH ($26.50 Down) with eyepieces for 171x, 131x, 96x, 67x, 48x — **$265**

3" EQUATORIAL ($43.50 Down) with eyepieces for 200x, 131x, 96x, 67x, 48x — **$435**

3" PHOTO-EQUATORIAL ($55.00 Down) with eyepieces for 200x, 171x, 131x, 96x, 67x, 48x — **$550**

4" ALTAZIMUTH ($46.50 Down) with eyepieces for 250x, 214x, 167x, 120x, 83x, 60x — **$465**

4" EQUATORIAL ($78.50 Down) with eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x — **$785**

4" PHOTO-EQUATORIAL ($89.00 Down) with eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x — **$890**

4" EQUATORIAL with clock drive **($98.50 Down)**, Model 160V, eyepieces as above — **$985**

4" EQUATORIAL with clock drive and metal pier **($107.50 Down)**, Model 166V, eyepieces as above — **$1075**

4" PHOTO-EQUATORIAL with clock drive and Astro-camera **($117.50 Down)**, with eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x, 25x — **$1175**

4" PHOTO-EQUATORIAL with clock drive, pier, Astro-camera **($128.00 Down)**, eyepieces for 375x, 300x, 250x, 214x, 167x, 120x, 83x, 60x, 38x, 25x — **$1280**

6" EQUATORIAL with clock drive, pier, 2.4" view finder, with eyepieces for 625x, 500x, 416x, 357x, 277x, 200x, 138x, 100x, 62x, 42x — **$5125**

6" PHOTO-EQUATORIAL as above but with 4" guide telescope, illuminated diagonal, UNIBALANCE, Astro-camera Model 330 — **$5660**

6" PHOTO-EQUATORIAL as above with addition of 3" Astrographic Camera Model 80 — **$6075**

Note These UNITRON Features

- LENSES are FULLY CORRECTED for spherical and chromatic aberration and are COATED for maximum brilliance and clarity of image. Optics especially designed for astronomical observation. AIR-SPACED OBJECTIVES.
- REFRACTOR type of design duplicates the performance of larger telescopes of other types. No mirrored surfaces to become oxidized. Superior definition to the very edge of the field.
- EYEPIECES of the HIGHEST QUALITY: Orthoscopic, Achromatized Symmetrical, Kellner, Huygens. Three to ten eyepieces included with each instrument.
- FINEST MATERIALS used throughout. DURALUMIN TUBE. Moving parts of BRASS carefully machined to close tolerances, and finished in CHROMIUM. No surplus components used.
- MODERN DESIGN based on time-tested engineering principles. HANDSOME APPEARANCE to which no illustration can do justice.
- EQUATORIAL MODELS have slow-motion controls for **both** declination and right ascension as well as convenient clamps on both axes. Sturdy TRIPOD (or PIER).
- ALTAZIMUTH MODELS have slow-motion controls for **both** altitude and azimuth as well as clamps for both co-ordinates. Sturdy TRIPOD.

Higher- and lower-power eyepieces available for all models. Prices include basic accessories, tripod and mounting, fitted wooden cabinets, and operating instructions.

HOW TO ORDER A UNITRON

Send check or money order in full or use our Easy Payment Plan, as described below. Shipments made express collect. Send 20% deposit for C.O.D. shipment. UNITRON instruments are fully guaranteed for quality, workmanship, and performance, and must meet with your approval or your money back.

Use Our EASY PAYMENT PLAN

UNITRON's popular Easy Payment Plan is a convenient and economical way to buy your UNITRON Refractor when you do not want to disturb your savings or when you haven't the total cost of the telescope immediately available. The down payment required is 10%. The balance due is payable over a 12-month period, and there is a 6% carrying charge on the unpaid balance. Your first payment is not due until 30 days after you receive the instrument, and if you should want to pay the entire balance due at that time, the carrying charge is canceled. (6" models available on special plan.)

PORTABILITY PLUS

UNITRON 2.4" Altazimuth

Here is the telescope that has long been America's most popular low-priced refractor.

The UNITRON 2.4" Altazimuth is a favorite not only with the beginning amateur, but is chosen by many owners of larger instruments as a second telescope because of its light weight and extreme portability. A newly designed suitcase-type cabinet is now being included to house the complete telescope with tripod and mounting, thus permitting even more convenient transport than ever.

The UNITRON 2.4" Altazimuth Refractor is priced at only $125 complete with tripod, sturdy mounting with micrometric slow-motion controls, four eyepieces, choice of UNIHEX Rotary Eyepiece Selector or star diagonal and erecting prism system, cabinet, and other accessories. Using our Easy Payment Plan, a mere 10% down payment of only $12.50 brings this UNITRON to you.

Get UNITRON's FREE Observer's Guide and Catalog on ASTRONOMICAL TELESCOPES

This valuable 38-page book is yours for the asking!

With artificial satellites already launched and space travel almost a reality, astronomy has become today's fastest growing hobby. Exploring the skies with a telescope is a relaxing diversion for father and son alike. UNITRON's handbook contains full-page illustrated articles on astronomy, observing, telescopes and accessories. It is of interest to both beginners and advanced amateurs.

Contents include—

- Observing the sun, moon, planets and wonders of the sky
- Constellation map
- Hints for observers
- Glossary of telescope terms
- How to choose a telescope
- Amateur clubs and research programs

UNITRON

INSTRUMENT DIVISION of UNITED SCIENTIFIC CO.
204-206 MILK STREET • BOSTON 9, MASS.

Please rush to me, free of charge, UNITRON's new Observer's Guide and Telescope Catalog 20-G.

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UNITRON INSTRUMENT DIVISION OF UNITED SCIENTIFIC COMPANY
204-206 MILK STREET · BOSTON 9, MASSACHUSETTS

how modern is your telescope?

☐ Reflector (Newton)	A.D. 1668
☐ Refractor (Fraunhofer)	1815
☐ Catadioptric (Schmidt)	1931
☐ Catadioptric (Maksutov)	1944

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The VEGA 6" MAKSUTOV

Length: 24" Weight: 37 lbs.

Including equatorial mount, electric drive, 4 eyepieces, solar filter, camera adapter, case: **$1675**

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De luxe kits contain:
★ 2 mirror blanks of PYREX-brand glass
★ 7 large metal cans of optical abrasives
★ Fast-polishing cerium oxide
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Size	*Thickness*	*Price*
4¼"	¾"	$ 6.00
6"	1"	$10.50
8"	1⅜"	$18.75
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12½"	2⅛"	$59.95

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BRANDON OCULARS

These orthoscopic oculars are the choice of the amateur as well as the professional astronomer. Seven sizes available: 4-mm., 6-mm., 8-mm., 12-mm., 16-mm., 24-mm., and 32-mm. focal lengths. Standard 1¼" outside diameter.
$15.95 each

Brandon Oculars may be purchased at —

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Cleveland Astronomics, 7618 Lawn Ave., Cleveland 2, Ohio

American Lens and Photo Co., 5700 Northwest Highway, Chicago 30, Ill.

Optron Laboratory, Box 23, D.V. Station, Dayton 6, Ohio

Adler Planetarium, 900 E. Achsah Bond Dr., Chicago 5, Ill.

Polaris Telescopic Shop, 14319 Michigan Ave., Dearborn, Mich.

Chuck's Telescopic-Optical Shop, 887 Sherbourne Dr., Inkster, Mich.

—or order direct. We will ship airmail.

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Formerly BRANDON INSTRUMENTS

GLEANINGS FOR ATM's

CONDUCTED BY ROBERT E. COX

A Mounting Made of Automobile Front-Wheel Assemblies

SEVERAL TIMES a year, my 6-inch portable reflector is used for observing demonstrations at boy scout encampments in this area. The instrument receives severe handling on such occasions, and is sometimes transported as far as 250 miles for instructing school classes and other groups. In addition, it is used for ordinary amateur observing and infrequent photography.

Several earlier mountings, both with wooden and metal tripods, never performed satisfactorily under these rugged conditions, but the one described here works well and stands up under rough handling. It is as rigid as can be expected of a portable instrument, yet retains its alignment and suffers no damage during transportation. It is easily set up and accurately aligned on the north celestial pole, making possible the use of setting circles.

To cut down the cost, I began by examining the used parts available at local salvage and auto junk yards. I found that the front hub and spindle assemblies of a car could be used to advantage. Units with tapered roller bearings were selected, because it is possible to preload that type of bearing to almost any degree desired and still not interfere with free rotation.

Two such units were obtained from an automobile wrecking yard for $3.75 each, including the cost of cutting them by torch from the car chassis and having all excess metal removed at the same time. To be sure of securing good bearings, one

J. Dexter Eoff's rugged 6-inch reflector has an offset declination counterweight.

The Eoff mounting head, seen here about half its actual size, has finely divided setting circles, an aid to star and nebula identification.

should carefully check their condition before cutting commences. Of course, new assemblies could be purchased, but at many times this cost.

At this point, it is necessary to have a moderate amount of machine work done, either commercially or in one's own shop. The wheel flange is removed from the hub, and the metal on the inner end of the spindles is turned to a disk, leaving it as large as possible. A hole is drilled in the opposite end of each spindle while it is still in the lathe, so an extension can be fitted and welded into the opening. The extension is turned true with the spindle's axis, permitting the addition of setting circles, and even a clock drive.

The photographs show the cradle of heavy welded steel plate that supports the hub forming the polar axis. The two parts are welded together at an angle equal to the observing latitude, but any small error can be taken care of when the instrument is set up. Two bubble levels were installed for this purpose. The second hub, forming the declination axis, was welded to the north end of the polar spindle at a right angle. This task was tricky and difficult. It is advisable just to spot-weld the two assemblies together first, checking to be sure the angle has not changed before completing the job.

Thus far, I have described the main steps required to use the wheel assemblies for a telescope mounting. Further steps depend on the design adopted, particularly for the counterweight. Not everyone will approve of my arrangement, which works all right in this case, however. The pictures show adequately the pipe assembly used to carry the counterweight, but $1\frac{1}{4}$" pipe is needed to secure rigidity, except for the $\frac{3}{4}$" nipple that fits into the side of the declination axis hub.

The main pier is of $2\frac{1}{4}$" hard-steel drill stem, which has walls about twice as thick as ordinary pipe. The three legs, welded at the bottom of the drill stem, have leveling screws at their lower ends. The telescope-tube cradle is made of reinforced heavy aluminum channel.

Without the control of slow motions or a clock drive, the telescope rotation on the roller-bearing axles is almost too smooth, so some form of brake is needed. Therefore, bolts with large heads have been inserted in tapped holes in the axle housings. These bolts may be turned against the axle shafts to act as brakes, introducing just the desired amount of drag. It is recommended that a flat ring be cut on the spindle surfaces just where the ends of the bolts strike, providing a greater braking surface.

After the instrument was assembled and adjusted indoors, only minor corrections were found necessary when it was first used in the field. With the tripod leveling screws and the spirit levels, alignment on the celestial pole is done quickly. Objects can be easily found in the field of a 1-inch eyepiece when the setting circles are used, and with care I can consistently place stars in an eyepiece of half that focal length.

Although costing only some $35, the mounting is substantial and heavy. The telescope and mounting on the stand weigh close to 80 pounds. It meets all the requirements for my 6-inch reflector, and for larger instruments the same design could be adopted, with truck-hub assemblies instead of those from passenger cars.

J. DEXTER EOFF
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Prices for Beral coating telescope mirrors: 4", $3.50; 6", $5.00; 8", $6.50; 10", $8.50; 12½", $12.50. Prices for sizes up to 37" diameter on request. Add Postage — Insurance for return mail.

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$1149	6 x 15 IF	360 ft.	Opera	$12.75
$1436	6 x 30 CF	395	"Zeiss"	18.75
$1435	6 x 30 IF	395	"Zeiss"	16.75
$1438	7 x 35 CF	341	"Zeiss"	20.75
$1437	7 x 35 IF	341	"Zeiss"	17.95
$1771	7 x 35 CF	341	American	23.50
$1439	7 x 35 CF	578	American*	35.00
$2191	7 x 50 CF	530	American**	42.50
$1106	7 x 50 CF	372	"Zeiss"	24.95
S–961	7 x 50 IF	372	"Zeiss"	22.50
$1503	7 x 50 CF	372	American	32.50
$1443	8 x 30 CF	393	"Zeiss"	21.00
$1229	8 x 30 IF	393	"Zeiss"	18.25
$1108	10 x 50 IF	275	"Zeiss"	26.75
$1442	20 x 50 CF	183	"Zeiss"	33.75
$1441	20 x 50 IF	183	"Zeiss"	31.75

*Wide-angle 11° **Wide-angle

All prices above plus 10% Federal tax.

Monoculars

Brand-new, coated optics, complete with pigskin case and neck straps.

Cat. No. $1576	6 x 30	$10.00	ppd.
Cat. No. $1577	8 x 30	11.25	ppd.
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Cat. No. $1303	7 x 50	14.75	ppd.
Cat. No. $1579	16 x 50	17.50	ppd.
Cat. No. $1580	20 x 50	20.00	ppd.

8-Power Elbow Telescope

8 x 50

This telescope has a brilliant-image 48° apparent field; actually 325 feet at 1,000 yards. Can be adjusted for focusing 15 feet to infinity. 2" achromatic objective, focusing eyepiece 28-mm. f.l., Amici erecting system. Turret-mounted filters: clear, red, amber, and neutral. Lamp housing to illuminate reticle for night use. Truly the biggest bargain you were ever offered. Original Gov't. cost $200.

Cat. No. $1686 Not Coated ..... $13.50 ppd.
Cat. No. $1975 Coated ..... $17.50 ppd.

Mirror Mounts

Cast aluminum, holds all of our mirrors with metal clips. Completely adjustable, assembled.

Cat. No. $1634 3-3/16" Mount for 4½" Tubing $4.00 ppd.
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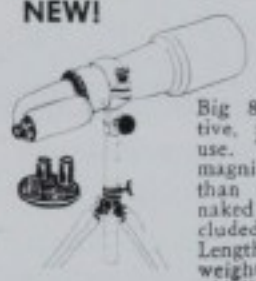
Cat. No. $1632 6" Mount for 7" Tubing . 6.50 ppd.

Prismatic Telescope

NEW!



80-mm. Objective

Big 80-mm.-diam. (3⅛") objective, for spotting or astronomical use. Will show stars of the 11th magnitude — 100 times fainter than the faintest visible to the naked eye. Table-top tripod included, extended 18", closed 13¾". Length of scope 16¼". Combined weight of scope and tripod is 5¼ lbs.

FIVE EYEPIECES

Power	Field at 1,000 yards	Exit pupil diam.	Relative Brightness
15x	122 ft.	5.4 mm.	29
20	122	4.0	16
30	61	2.7	7
40	49	2.0	4
60	32	1.3	1

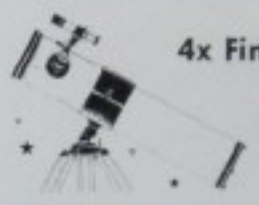
Cat. No. $2052 ..... $59.50 ppd.

60-mm.-diam. Scope. Same as above but with smaller objective. Equipped with same five eyepieces — 15x, 20x, 30x, 40x, 60x. With tripod.

Cat. No. $1721 ..... $42.95 ppd.

4¼" Reflector Telescope

35x — 175x
4x Finder — Wood Tripod



From the mysterious craters of the moon to the fabulous rings of Saturn, this high-quality telescope will give you many pleasurable hours of crystal-clear astronomical viewing. Contains an f/6 parabolic mirror which gives a 50-per-cent brighter image than the ordinary f/10. Two coated eyepieces, 35x and 175x; rack-and-pinion focusing; sun filter; and 4x focusing finder. Its short tube, 27¾" long, and collapsible wood tripod (33" closed, 60" open), make for portability, stability, and compactness. Finished in white enamel with black trim. Although priced low, this is definitely not a toy. Imported. Shipping weight about 20 lbs.

FREE BOOK with Scope: **DISCOVER THE STARS.**

Cat. No. $2273 ..... f.o.b. Lynbrook, N. Y., $59.50

Astronomical Mirrors

These mirrors are of the highest quality. Aluminized, with silicon-monoxide protective coating. You will be more than pleased with their performance.

Cat. No.	Diam.	F.L.	ppd.
$1429	3-3/16"	42"	$ 8.70
$1506	4¼"	45"	13.50
$1507	6"	60"	25.00
$2188	6" parabolic	48"	49.50

Mounted Eyepieces

The buy of a lifetime at a great saving. Perfect war-surplus lenses set in black-anodized standard aluminum 1¼" O.D. mounts.

Cat. No.	F.L.	Type	ppd.
$2192	6 mm. (¼")	Orthoscopic	$13.25
$1851	6 mm. (¼")	Ramsden	4.75
$1853	12.5 mm. (½")	Ramsden	4.50
$1207	12.5 mm. (½")	Symmetrical	6.00
$1251	16 mm. (⅝")	Erfle (wide-angle)	12.50
$1257	16 mm. (⅝")	Orthoscopic	12.50
$1209	18 mm. (¾")	Symmetrical	6.00
$1211	22 mm. (27/32")	Kellner	6.00
$1835	27 mm. (1-1/16")	Kellner	4.50
$1355	32 mm. (1¼")	Plossl	12.50
$1253	35 mm. (1⅜")	Symmetrical	8.00
$1255	55 mm. (2-3/16")	Kellner	6.00
$1485	56 mm. (2¼")	Symmetrical	6.00

COATED LENSES 75 cents extra.

An Economical Eyepiece

This mounted eyepiece has two magnesium-fluoride-coated achromatic lenses 29 mm. in diameter. Excellent definition. E.F.L. 1¼". Cell fits 1¼" tubing.

Cat. No. $1911 Coated ..... $5.90 ppd.
Cat. No. $1991 Not Coated ..... 5.25 ppd.

Rack-&-Pinion Eyepiece Mounts

Here is a wonderful opportunity for you to own a most mechanically perfect Rack-&-Pinion Focusing Eyepiece Mount with variable tension and adjustment. Will accommodate a standard 1¼" eyepiece, positive or negative. The body casting is made of lightweight aluminum with black-crackle paint finish, focusing tube of chrome-plated brass. Focusing tube for refractors has a travel of 4", for reflectors 2", and will fit all size tubing.

REFRACTOR TYPE

Cat. No. $1494 for 2⅛" I.D. Tubing ..... $12.95 ppd.
Cat. No. $1495 for 3¼" I.D. Tubing ..... 12.95 ppd.
Cat. No. $1496 for 4⅜" I.D. Tubing ..... 12.95 ppd.

REFLECTOR TYPE

Cat. No. $1976 (less diagonal holder) ..... $8.50 ppd.
Cat. No. $1982 DIAGONAL HOLDER ..... 1.00 ppd.

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• • • *Air-spaced* • • •

"THOSE WHO KNOW" BUY FROM US BECAUSE:

1862
1860
1473
1471

Each lens is thoroughly tested and guaranteed to resolve to Dawes' limit. They are corrected for the C and F lines (secondary chromatic aberration). The zonal spherical aberration and the chromatic variation of spherical aberration are negligible. The cells are machined to close tolerances so that they fit directly over or into our standard aluminum tubing, eliminating any mounting problems. Test a lens, or have any qualified person test it; we are certain that you will be satisfied. If not, take advantage of our money-back guarantee. *We offer the lowest-priced, hand-corrected, precision, American-made astronomical objective,* mounted in an aluminum cell. Our reputation for high-quality lenses has established us as the most reliable source in the industry.

HARD-COATED ON 4 SURFACES.

3¼" APERTURE f/15 — 48" F. L.	Cat. No. $1447	NOT COATED	$28.00	ppd.
	Cat. No. $1471	COATED	32.00	ppd.
4⅛" APERTURE f/15 — 62" F. L.	Cat. No. $1472	NOT COATED	$60.00	ppd.
	Cat. No. $1473	COATED	69.00	ppd.
6" APERTURE f/10 — 60" F. L.	Cat. No. $1861	UNMOUNTED	$150.00	ppd.
	Cat. No. $1860	MOUNTED	175.00	ppd.
6" APERTURE f/15 — 90" F. L.	Cat. No. $1863	UNMOUNTED	$150.00	ppd.
	Cat. No. $1862	MOUNTED	175.00	ppd.

"BIG" ACHROMATIC TELESCOPE OBJECTIVES

We have the largest selection of diameters and focal lengths in the United States available for immediate delivery. These are perfect magnesium-fluoride coated and cemented Gov't. surplus lenses made of finest crown and flint optical glass. Not mounted. Fully corrected. Tremendous resolving power.

● ALUMINUM TUBING and CELLS are in stock ●

Cat. No.	Diam.	F.L.	ppd.
$1476	(2⅛")	(10")	$12.50
$1112	(2⅛")	(11¾")	12.50
$1110	(2⅛")	(13")	12.50
S–958	(2⅛")	(15½")	9.75
$1145	(2⅛")	(20")	12.50
S–952	(2⅛")	(23½")	12.50
$1431	(2⅛")	(30")	12.50
$1432	(2⅛")	(40")	12.50
$1520	(2⅛")	(50")	$12.50
S–851	(3-1/16")	(15")	21.00
$1158	(3⅛")	(19½")	28.00
S–822	(3-3/16")	(24½")	22.50
$1092	(3¼")	(26")	28.00
$1093	(3¼")	(28")	28.00
$1139	(3¼")	(30")	28.00
S–955	(3¼")	(34½")	28.00
S–957	(3¼")	(40")	$30.00
$1155	(4")	(34½")	60.00
$1460	(4¼")	(36")	60.00
$1159*	(4⅜")	(42")	60.00
$1225	(4⅜")	(42")	67.50
$1474*	(5-1/16")	(24¾")	75.00
$1475	(5-1/16")	(24¾")	85.00

*Not coated.

A. JAEGERS
6915 MERRICK RD., LYNBROOK, N. Y.

An Australian Amateur's Grinding Machine

AN INTEREST in things mechanical and astronomical prompted me to build the grinding machine pictured here. It has several important design features: a friction drive that provides instantly variable speeds, a bath in which the tool and mirror are completely immersed during polishing, and a ball joint in the pin driving the mirror that enables the mirror to be force-turned by the rotating tool.

The machine grinds, polishes, and figures mirrors to a high degree of accuracy without any handwork. At present it will handle mirrors up to 8-inch diameter, but soon will be modified for 12-inch ones. This all-metal machine contains no expensive parts; odds and ends available in my workshop were built into an iron stand.

The reversible ¼-horsepower single-phase motor enables the operator to change the direction of rotation by throwing a switch. A belt drive from the motor turns the large disk at the lower right in the picture. Mounted to the left on the disk's shaft is a long flat pulley over which passes a flat belt that drives a larger flanged pulley mounted above and toward the front of the frame. The shaft of the large pulley also carries a 4½" rubber-tired disk (behind the post), which may be shifted to the left or right by means of a diagonal control rod running through a fork mounted between the pulleys and the disk.

The control rod slides in a slot at the front of the machine's frame. Graduations allow the operator to record the pulley positions. The 4½" tire rolls on a flat horizontal plate 13" in diameter; the tire's distance from the axis of this plate controls the speed of rotation of the long vertical shaft at the left. The rotation rate may be varied from 54 to 96 turns per minute, while a change of pulleys on the motor gives a further range.

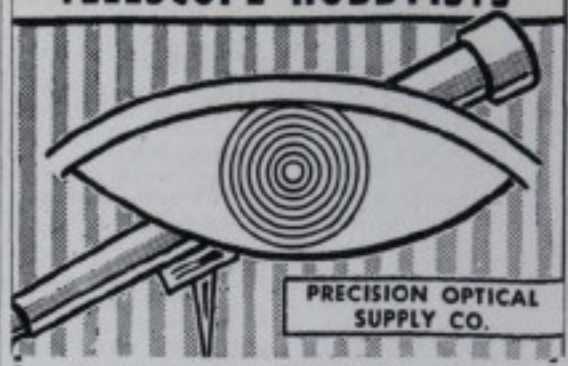
The vertical shaft drives a leather belt which spins the shaft attached to the grinding tool (upper right). When the tool turns, the mirror turns too, thus keeping the grinding effort well distributed over both surfaces.

On top of the vertical shaft, at the left, may be seen the calibrated eccentric drive for the crank arm, which gives strokes from ½" to 11". Under the crank arm and near the mirror is the fork that positions the arm for side strokes and enables it to be extended for offset strokes. Calibrations are marked on the crank arm to permit exact resetting.

At top center, a spring holding the arm

This machine was built by Beau Watson from surplus parts and discarded metal, and was designed not only to grind mirrors but to polish and figure them.

TELESCOPE HOBBYISTS



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SS08A Ecliptic-based star map — with equatorial grid and names
SS08 Ecliptic-based star map — with equatorial grid, **without** names
SS08B Ecliptic star map list — positions and magnitudes for 224 stars
SS05 Nine-inch protractor on paper — for planet orbit drawings
SS11 Inner planet chart — orbits of Mercury, Venus, Earth, Mars
SS12 Outer planet chart — orbits of Mercury to Saturn
SS01A Special rectangular co-ordinate paper — for star maps
SS02 Polar co-ordinate paper — for circumpolar star maps

Price for each item listed above: 1 to 9 sheets, 10 cents each; 10 to 24 sheets, 8 cents each; 25 to 99 sheets, 6 cents each; 100 or more, 5 cents each.

From Stetson's *Manual of Laboratory Astronomy*, the chapter "Star Chart Construction" is available as a separate booklet, at 50 cents per copy.

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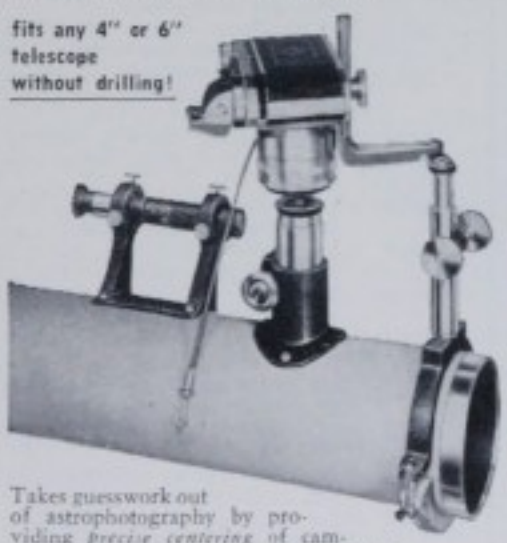

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Kellner 12.7-mm. f.l. (½")	9.50
Kellner 18-mm. f.l. (¾")	9.50
Kellner 30-mm. f.l. (1-3/16")	12.50
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Orthoscopic 4-mm. f.l. (5/32")	14.50

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The Criterion Revolving Turret holds three eyepieces so that, as desired, the power of the telescope can be changed by merely turning the turret to a different ocular. Click stop insures positive and accurate positioning of each eyepiece. Turret holds eyepieces of standard 1¼" outside diameter. Fits into the holder of any refractor or reflector telescope that uses 1¼" eyepieces. Requires no alteration or adjustment and can be attached as easily as putting eyepiece into scope. Made of brass and aluminum with polished chrome-plated barrels.

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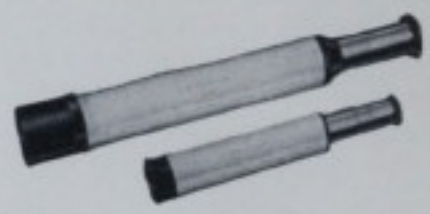

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S-52	1.50"	6½" to 7½"	10.00
S-53	1.50"	8½" to 9½"	10.00
S-54	1.75"	9½" to 10½"	12.50
S-55	2.00"	11" to 11½"	14.95
S-56	2.50"	Specify tube I.D.	19.95

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Beau Watson's 6-inch reflector.

down keeps pressure on the mirror, while weights can be applied directly above the mirror if desired. By sliding the vertical shaft in its bearings, the arm may be raised or lowered to keep it horizontal for any thickness of glass. It can be replaced by an attachment for edging and beveling mirror blanks. The ball joint allows the crank arm to be lifted clear for removal of the mirror for testing.

Variations in mirror temperature often cause difficulty in obtaining the desired figure. To overcome this, I have completely immersed mirror and tool in a bath in the high-sided pan at upper right, with a sealed entrance for the drive shaft. A thin solution of water and jeweler's rouge, agitated to prevent settling, provides even temperature and eliminates dust. This is common practice in commercial mirror making shops.

Attached to the crank arm is an extension which places an adjustable bias on the mirror. Thus the mirror may be made to bear more heavily on the tool at any desired point.

With this machine, I made the 6-inch f/12.5 mirror, figured to a spheroid, of the telescope shown here. The altazimuth mounting has slow motions on both axes. Definition is excellent, and magnifications up to 300 can be used under good seeing conditions. The platform surrounding the telescope pier keeps the observer's feet dry when dew is heavy, and the higher pier is advantageous in that it lifts the mirror farther from disturbing ground currents and moisture.

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O. MAGNUSSON
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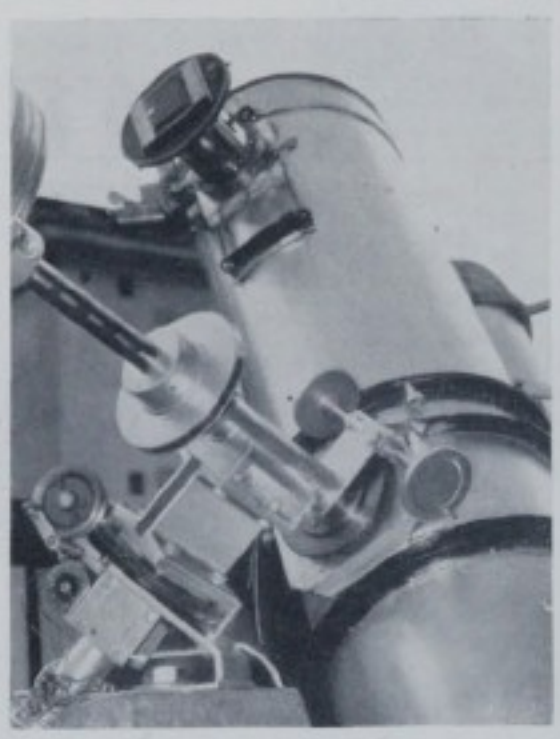
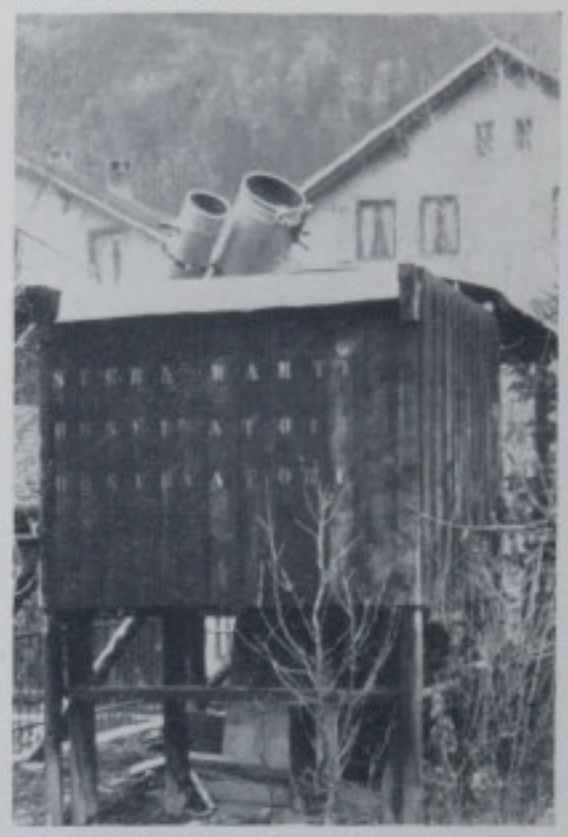
A Swiss Amateur's Observing Station

TWO Newtonian telescopes, both mounted on the same equatorial head, comprise my observing equipment. The combination is supported on a sturdy concrete pier that extends into the ground below the elevated platform of the observatory pictured here.

The larger reflecting telescope has a 13-inch mirror and is used for visual and photographic observations, including study of the sun. The smaller instrument, with an 8.7-inch mirror, is employed chiefly for guiding and has illuminated cross-hairs. Both telescopes have about the same focal ratio, f/5.5.





The 13-inch mounting and upper tube are seen at the left; both telescopes are visible in the picture above.

The equatorial mounting contains a synchronous-motor drive for automatic tracking of celestial objects and star fields. Except for the construction of the electrical slow motion and the large tubes, all the work was done by me, including the observatory, as well as the grinding and polishing of the mirrors.

I am a member of the Astronomical Society of Switzerland.

K. GYSLER-ABPLANALP
Hotel Post
Meiringen, Switzerland

CORRECTIONS

In Table I on page 504 of the June issue, the entry for a 16-inch f/4 mirror should read 0.250245 inch, not 0.250254. The error was pointed out by A. G. Fries, Chicago, Illinois.

In last month's issue, page 145, first column, fifth paragraph, line five, replace "of the moon's shadow" with "of the earth's shadow." The error was pointed out by Bruce Ecker, Farmingdale, New York.

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A dark blue fabrikoid binder priced at $3.50 each, postpaid in the United States; $4.00 in Canada. Two sizes: Binder C is for volumes up to XVIII; Binder D is for volume XIX and after. When ordering, please specify the volume number for which the binder is to be used.

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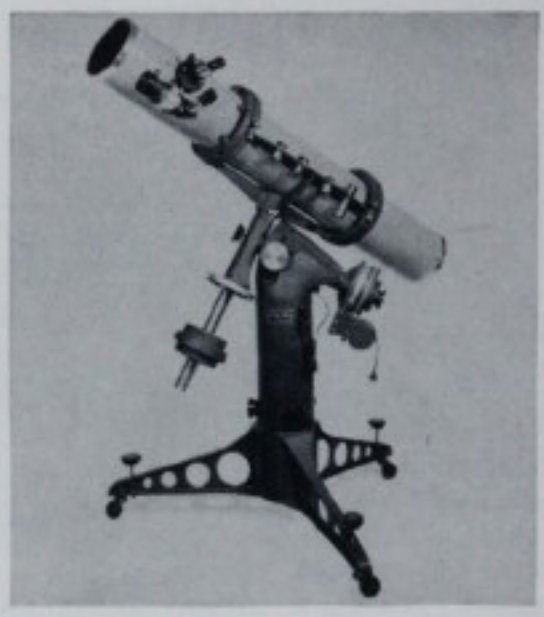

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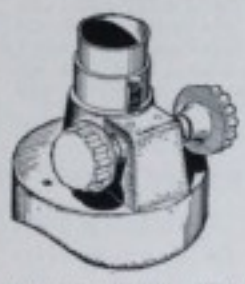

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CELESTIAL CALENDAR

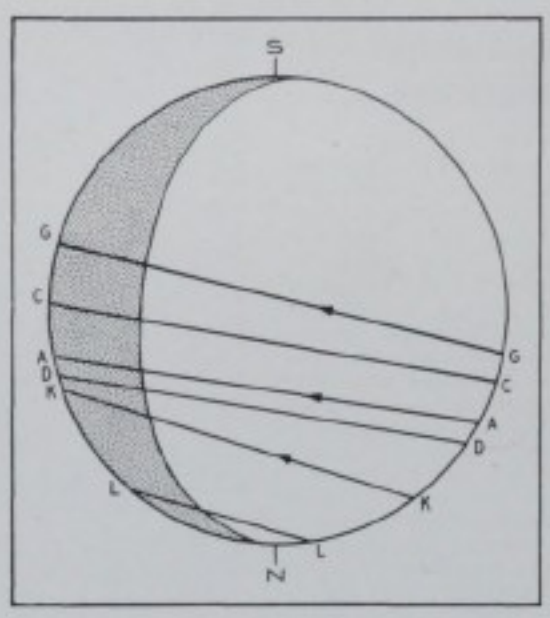
Universal time (UT) is used unless otherwise noted.

Occultation of the Hyades and Aldebaran

THE waning gibbous moon will pass in front of the Hyades star cluster and 1st-magnitude Aldebaran during the night of October 8-9, the fifth such event of this year for North America. The times of disappearance and reappearance of the occulted stars can be easily predicted for your locality from the data given in the Occultation Supplement (page 99, December, 1959, issue). A map of the Hyades stars was published on page 380 in April, 1960.

These events will be seen throughout the continental United States and much of Canada. While a telescope is needed for observing the occultations of the other stars, that of Aldebaran can be watched in binoculars.

The chart shows the apparent paths of Aldebaran relative to the moon as seen from six stations selected from the following table. In each case, the star disappears behind the bright edge of the moon and reappears at the dark edge.



This chart shows the apparent paths of Aldebaran behind the moon during the occultation of October 8-9. This event will be visible from 10 of the 12 United States and Canadian standard stations, tracks for six being plotted.

PREDICTED TIMES FOR OCTOBER 8-9 OCCULTATION OF ALDEBARAN

Station	*Location*	*Disapp.*	*Reapp.*	*Time*
A	Massachusetts	4:10 a.m.	5:31 a.m.	EST
B	Montreal	4:11 a.m.	5:24 a.m.	EST
C	Washington, D. C.	3:58 a.m.	5:27 a.m.	EST
D	Toronto	3:58 a.m.	5:17 a.m.	EST
F	Illinois	2:30 a.m.	3:56 a.m.	CST
G	Texas	2:03 a.m.	3:36 a.m.	CST
H	Denver	1:09 a.m.	2:23 a.m.	MST
I	New Mexico-Arizona	0:50 a.m.	2:13 a.m.	MST
K	California	11:47 p.m.	0:49 a.m.	PST
L	Oregon	0:11 a.m.	0:42 a.m.	PST

At stations **J** (Edmonton, Alberta) and **M** (Vancouver, British Columbia), Aldebaran will just miss being occulted by the moon.

OCTOBER METEORS

Before dawn on October 20th and 21st, an observer can count up to about 25 meteors per hour, when the Orionid shower attains its maximum activity. The moon will not interfere, being new on the 20th. The radiant is about 10° northeast of Betelgeuse, and the shower lasts roughly eight days.

Although the Taurid shower begins in late October and reaches maximum on November 5th, it will be masked by the light of the moon, which is full on November 3rd.

WILLIAM H. GLENN

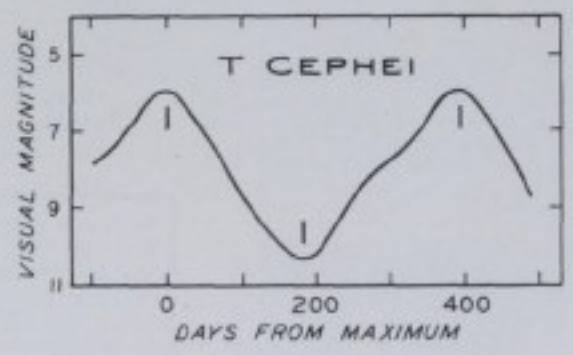
MOON PHASES AND DISTANCE

Full moon	October 4, 22:17
Last quarter	October 12, 17:26
New moon	October 20, 12:03
First quarter	October 27, 7:34
Full moon	November 3, 11:58

	Distance	Diameter
October		
Apogee 12, 13h	251,200 mi.	29′ 33″
Perigee 24, 20h	229,000 mi.	32′ 25″
November		
Apogee 9, 9h	251,600 mi.	29′ 31″

T CEPHEI

AMATEUR observers of long-period variable stars have for many years made T Cephei a favorite object. Because the star changes between magnitudes 6 and 10 during a typical 13-month cycle, it never requires an instrument larger than a 3-inch refractor, and its circumpolar location permits observing throughout the year for most of North America.



The mean light curve of the long-period variable T Cephei, derived by Leon Campbell from observations made by members of the American Association of Variable Star Observers. The hesitation during the rise to maximum is typical of the light curves of variables with periods near 400 days.

In 1960, greatest brightness will occur about November 9th, according to predictions by the American Association of Variable Star Observers. For several weeks before and after that date, T Cephei should be readily recognizable in binoculars. Labeled in the Skalnate Pleso *Atlas of the Heavens*, the variable lies at 21h 08m.9, +68° 17′ (1950 co-ordinates), about 3° southwest of Beta Cephei.

The light changes of T Cephei were discovered in 1878 by the Moscow astronomer W. Ceraski. As with other long-period stars, the cycle length is inconstant; in recent years the interval between successive maxima has been as long as 411 days and as short as 379. According to Leon Campbell, the average period is 389.6 days.

In the accompanying mean light curve, there is a noticeable hump on the ascending branch. A. A. Nijland, who observed this variable for many decades at Utrecht Observatory, stated that the hump was present in every cycle, while the descending branch was always smooth. Nijland described the color of T Cephei as 5.1, in terms of the numerical scale explained on page 342 of Sky and Telescope for April, 1960. This value corresponds to deep yellow, not the red or orange that might be expected from the spectral type, *M*6e. Readers may wish to check the visual color of T Cephei for themselves.

VARIABLE STAR MAXIMA

October 8, W Andromedae, 021143, 7.4; 12, R Aurigae, 050953, 7.7; 12, V Cancri, 081617, 7.9; 14, R Lyncis, 065355, 7.9; 15, T Herculis, 180531, 8.0; 21, χ Cygni, 194632, 5.2; 22, V Canum Venaticorum, 131546, 6.8; 25, R Virginis, 123307, 6.9; 26, R Centauri, 140959, 5.9; 29, U Octantis, 131283, 7.9; 31, RS Herculis, 171723, 7.9; 31, T Pavonis, 193972, 8.0.

November 9, T Cephei, 210868, 6.0.

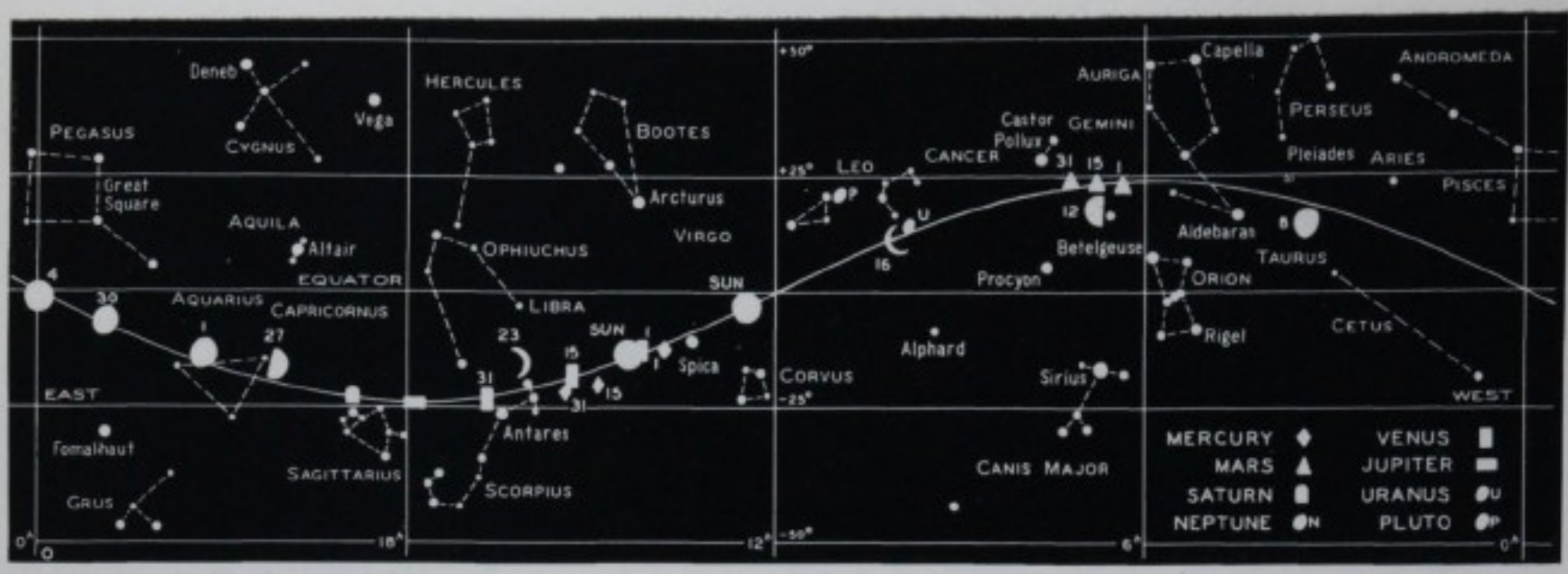
These predictions of variable star maxima are by the AAVSO. Stars are listed only if brighter than magnitude 8.0 at an average maximum. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for their maxima. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted visual magnitude.

MINOR PLANET PREDICTIONS

Metis, 9, 8.7. October 3, 2:21.1 +6-30; 13, 2:13.4 +6-01; 23, 2:03.8 +5-31. November 2, 1:53.8 +5-08; 12, 1:44.9 +4-58; 22, 1:38.3 +5-06. Opposition on October 25th.

Urania, 30, 10.0. October 3, 2:42.6 +19-38; 13, 2:36.6 +19-24; 23, 2:28.0 +18-52. November 2, 2:18.3 +18-07; 12, 2:09.0 +17-15; 22, 2:01.9 +16-26. Opposition on October 30th.

After the asteroid's name are its number and the approximate visual magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other dates shown. All positions are for 0h Universal time on the respective dates.

Mercury reaches greatest eastern elongation, 25° from the sun, on October 15th. Unfavorably placed for Northern Hemisphere observers, it may be glimpsed very low in the southwest after sunset.

Venus is an object of magnitude −3.4 moving eastward across Libra, and setting about 1½ hours after the sun. A small telescope will show this planet as a gibbous disk, 12″ in diameter and 86-percent illuminated in mid-October. On the 28th, Venus will pass 3° north of the 1st-magnitude star Antares.

The moon, as an evening crescent, moves by several planets between October 22nd and 25th, passing 6° north of Venus on the afternoon of the 22nd, 5° north of Jupiter on the afternoon of the 24th, and 4° north of Saturn the following day.

Mars is conspicuous in Gemini during early morning hours, rising about 10 p.m., local time, by midmonth. The planet will then be magnitude +0.1 and 88 million miles from the earth; telescopically, its reddish disk will be 9″.9 in diameter. The waning moon passes about 5° south of Mars at 22h Universal time on the 11th.

Jupiter is a prominent evening object of magnitude −1.6, setting about 3½ hours after the sun on October 15th. Its slightly flattened disk then measures 33″.2 in polar diameter and 35″.6 in equatorial.

Saturn, in Sagittarius east of Jupiter, reaches eastern quadrature on the 5th, and may be viewed low in the southwest during early evening hours. In midmonth, it is magnitude +0.7, and the disk has an equatorial diameter of 16″.4. Saturn's ring system, 37″.0 in longest diameter, continues to present its northern face to the earth, and is inclined at an angle of 25°.3 to our line of sight.*

Uranus rises about two hours after local midnight, and may be viewed in binoculars as a 6th-magnitude object. Located in Leo, at right ascension 9h 48m.8, declination +13° 58′ (1950 co-ordinates), on October 15th, this distant planet appears in telescopes as a tiny disk, 3″.6 in diameter.

Neptune is too close to the sun to be visible this month.

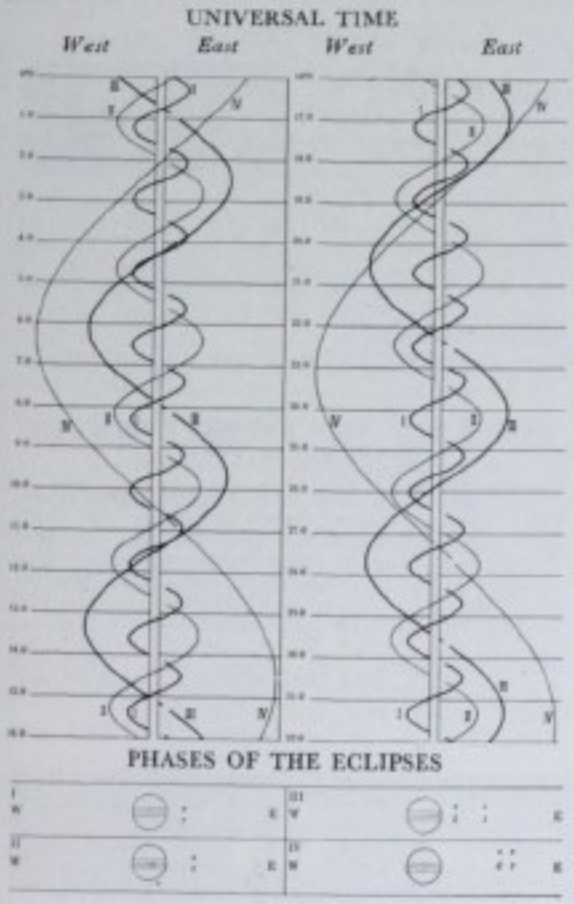
WILLIAM H. GLENN

JUPITER'S SATELLITES

The curves in the accompanying chart show the positions of Jupiter's four bright moons, as seen in an inverting telescope, with north at the bottom and east at the right. Each horizontal line is for 0h Universal time on the date specified, and the intersections of the line with the curves indicate the places of the satellites at that time. For other Universal times, interpolate between the 0h lines. The double vertical lines represent the planet's disk.

The lower section is intended to aid observations of the eclipses of Jupiter's moons; *d* is the point of disappearance of the satellite in Jupiter's shadow, *r* is the point of reappearance. The chart is from *The American Ephemeris and Nautical Almanac;* for further explanation, see page 446 of Sky and Telescope for May, 1960.

Jupiter's Satellites in October



MINIMA OF ALGOL

October 1, 4:39; 4, 1:27; 6, 22:16; 9, 19:05; 12, 15:53; 15, 12:42; 18, 9:31; 21, 6:19; 24, 3:08; 26, 23:57; 29, 20:46.

November 1, 17:35; 4, 14:24; 7, 11:12.

These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of the star's least brightness.

UNIVERSAL TIME (UT)

TIMES used in Celestial Calendar are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. To obtain daylight saving time subtract 4, 5, 6, or 7 hours, respectively. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown. For example, 6:15 UT on the 15th of the month corresponds to 1:15 a.m. EST on the 15th, and to 10:15 p.m. PST on the 14th.

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Stock #30,406-Y..... 18 mm..... 14.50 ppd.
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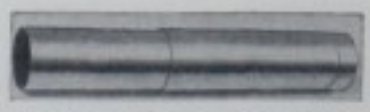

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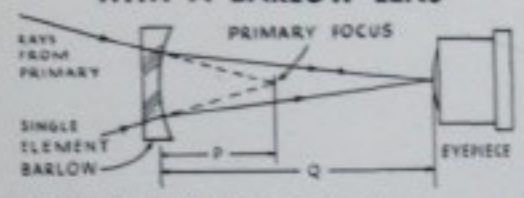

WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.

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Stock #30,200-Y...Mounted Barlow lens....**$8.00 ppd.**

UNMOUNTED 3X BARLOW LENS

These lenses are made for telescopes that have smaller-diameter eyepieces than the standard 1¼" size. Mount one between the eyepiece and objective, and triple your power. Instructions included. Single-element lens, focal length −1-5/16", unmounted.

Stock #30,185-Y....0.932" diam.....**$3.50 ppd.**
Stock #30,328-Y....0.912" diam.....**$2.50 ppd.**

3X ADJUSTABLE-DIAMETER BARLOW LENS

For telescopes with eyepieces smaller than the standard 1¼" outer-diameter size. Prongs on mount can be opened or closed to fit tubes from 13/16" to 1" outer diameter. Directions for using included.

Stock #30,339-Y.....**$5.00 ppd.**

MORE POWER FROM YOUR JAPANESE TELESCOPE

Mounted Barlow for Japanese Telescopes

By inserting this single-element lens in the eyepiece end of your Japanese telescope, and putting your regular eyepiece in the end of the Barlow tube, you can increase your telescope's power up to three times. Thus, instead of 60x, you will get 120x or 180x. Barlow is mounted in two pieces of telescoping brass tubing each 4" long, satin chrome plated on the outside. Inner diameter of large tube and outer diameter of small tube are 0.965", the standard size for most Japanese telescopes. Measure yours before ordering. 0.965" is approximately 31/32" or 24.5 mm.

Stock #30,370-Y.....**$6.00 ppd.**

BARGAIN! MOUNTED ACHROMATIC BARLOW LENS

2-element, low-reflection-coated, negative achromat which will increase the power of your telescope over 3 times. The short focal length (−1.74") allows the lens to be used close to the primary focus, eliminating the need for long cumbersome tubes as in most long-focus Barlow systems. Outside diameter of tube, 1¼" (standard eyepiece size). Your standard eyepieces will fit in the other end. Spacers are included to vary the power. Complete directions.

Stock #30,374-Y.....**$15.00 ppd.**

OPERATE YOUR TELESCOPE'S CLOCK DRIVE FROM YOUR AUTO BATTERY

This small inverter supplies 110-volt, 60-cycle electricity from your 12-volt car battery to operate your clock drive anywhere in the field. Can also be used to operate an electric shaver on trips. 20-watt rating; size, 2½" x 2½" x 3"; weight, 2 lbs. Easily fits in glove compartment.

Stock #50,346-Y....12-volt only.....**$14.95 ppd.**

EQUATORIAL MOUNT and TRIPOD with CLOCK DRIVE

Heavy-duty mount. Drive operates on 110-volt, 60-cycle, a.c. house current. Follows motion of stars smoothly. 32" tripod legs included.

Stock #85,081-Y....**$69.00** f.o.b. Barrington, N. J.

Same mount as above, without clock drive, for 8" or smaller reflectors and for 4" or smaller refractors.

Stock #85,023-Y.....New Low Price.....**$39.50** f.o.b. Barrington, N. J.

STARS THAT GLOW IN THE DARK

Transform your den or bedroom into a realistic night sky. Schools, too, can set up authentic sky scenes showing constellations, planets in a dark room for daytime lectures or explanations of earth and space science. Equally attractive as a means of making your children's room a fairyland, where their canopy of stars will make them welcome rather than fight "lights out." Set consists of 125 luminous star decals made of a safe, nonradioactive phosphor. Stars glow after exposure to strong light.

Stock #9298-Y.....**$1.00 ppd.**

MAP OF THE MOON

Edmund Scientific Co. strongly recommends this moon map. 35" x 46" photographic reproduction of the full moon — a very helpful aid. It is in black and white and has all named lunar formations clearly marked. In addition, it gives a complete index to their locations and much valuable information on the moon.

Stock #9297-Y.....**$1.00 ppd.**

PORTRAIT OF THE UNIVERSE

All the astronomical phenomena actually "sat" for their portraits before the camera telescopes of Mount Wilson, Palomar, Lick, and Yerkes observatories. Any amateur will find these thrilling photographs and the pertinent data included of great value. Each picture, 6" x 6". Handy spiral binding. Covers planets, solar phenomena, star clusters, and so forth. 32 black-and-white photographs.

Stock #9296-Y.....**$1.95 ppd.**

WAR-SURPLUS! AMERICAN-MADE!

7 x 50 BINOCULARS

Big savings! Brand new! Crystal-clear viewing — 7 power. Every optical element is coated. An excellent night glass — the size recommended for satellite viewing. Individual eye focus. Exit pupil 7 mm. Approx. field at 1,000 yds. is 376 ft. Carrying case included. American 7 x 50's normally cost $195. Our war-surplus price saves you real money.

Stock #1533-Y.....Only **$55.00 ppd.** (Tax included)

Mounted Ramsden Eyepieces

Standard 1¼" Diameter

Our economy model, standard-size (1¼" O.D.) eyepiece. We mounted two excellent quality plano-convex lenses in black anodized aluminum barrels instead of chrome-plated brass to save you money. The clear image you get with these will surprise you. Directions for using short focal length eyepieces are included with both the ¼" and ½" models.

Stock #30,204-Y.....¼" focal length.....**$4.75 ppd.**
Stock #30,203-Y.....½" focal length.....**$4.50 ppd.**

STAR AND SPACE MAPS

Three giant maps: 1. THE SOLAR SYSTEM, 50" x 38", showing planet statistics; detailed moon map; 12 telephoto pictures of moon, sun, planets. 2. WORLD STAR CHART, 50" x 38"; locates stars for any time of year, any position on earth. 3. MAP OF THE SOLAR SYSTEM, 35" x 48"; shows planets, zodiac, and so on.

Stock #9245-Y....Set of 3 maps.....**$1.25 ppd.**

8" SETTING-CIRCLE SET

Stock #50,133-Y..Complete set ..... **$3.00 ppd.**
Stock #60,078-Y..360° declination circle only **$1.60 ppd.**
Stock #60,079-Y..24-hour right-ascension circle only **$1.60 ppd.**

5¾" SETTING-CIRCLE SET

Stock #50,190-Y..Complete set ..... **$2.50 ppd.**
Stock #60,080-Y..360° declination circle only **$1.35 ppd.**
Stock #60,081-Y..24-hour right-ascension circle only **$1.35 ppd.**

LARGE ERFLE EYEPIECE 1½" F.L.

War-Surplus Bargain — Gov't. Cost Approx. $100

Large telescopes should have one of these for low-power viewing. Apparent field of view 65°. Also use with the 24"-focal-length Aerial Camera lens to make a 16-power wide-field telescope or a 27-power scope with one of the 40"-focal-length Aerial Camera lenses. Low-reflection-coated, 5-element lens system. Field lens of Eastman Kodak's rare-earth glass for better aberration correction. Has diopter scale. Smooth focusing ⅜" movement. Outside diameter of attaching threads, 3" — 32 threads per inch. Clear aperture of eye lens 2", field lens 1-25/32". Weight 3½ lbs.

Stock #50,091-Y.....**$9.95 ppd.**

ADAPT GIANT ERFLE TO STANDARD TELESCOPE EYEPIECE SIZE

This adapter lets you use our Giant Erfle with any telescope that has a standard 1¼"-diameter eyepiece holder. Of course, you won't get the full field of the Erfle, but you will get a wider field than with a regular eyepiece. Adapter is made of black anodized aluminum tubing approx. 2¼" long and 3⅜" wide.

Stock #50,358-Y.....**$3.95 ppd.**

Attention! For Beginners, Junior Astronomy Clubs, Boy and Girl Scouts, School Science Clubs

MAKE 8X ASTRONOMICAL SCOPE with Low-Cost Beginner's Kit!

Every boy and girl of today dreams of being a part of the exploration of outer space. That desire makes building his own telescope a real thrill. Now anyone of Cub Scout or Brownie age on up can make his own astronomical 8-power telescope in one evening, without tools or machinery. Here is an ideal, attractive group project for scouts, junior astronomy clubs, or similar groups. (See special quantity prices.) Scope is powerful enough to show craters of the moon, Jupiter's satellites, and many stars not visible to the naked eye. Kit includes objective lens, field lens, eye lens, glare stops, kraftboard tubes, cadmium-plated metal ferrules, and other parts to build an 18"-long, 1¾"-diameter telescope of 8 power.

Stock #70,238-Y.....**$3.00 ppd.**

SPECIAL QUANTITY PRICES

Stock #70,239-Y.... 5 kits.....**$12.50 ppd.**
Stock #70,240-Y....10 kits.....**$22.50 ppd.**

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128 Pages! Over 1000 Bargains!

Fantastic variety — rarely before have so many lenses, prisms, optical instruments, and components been offered from one source. Probably the greatest assembly of bargains in all America. Imported! War Surplus! Hundreds of other hard-to-get optical items. Many science and math learning and teaching aids.
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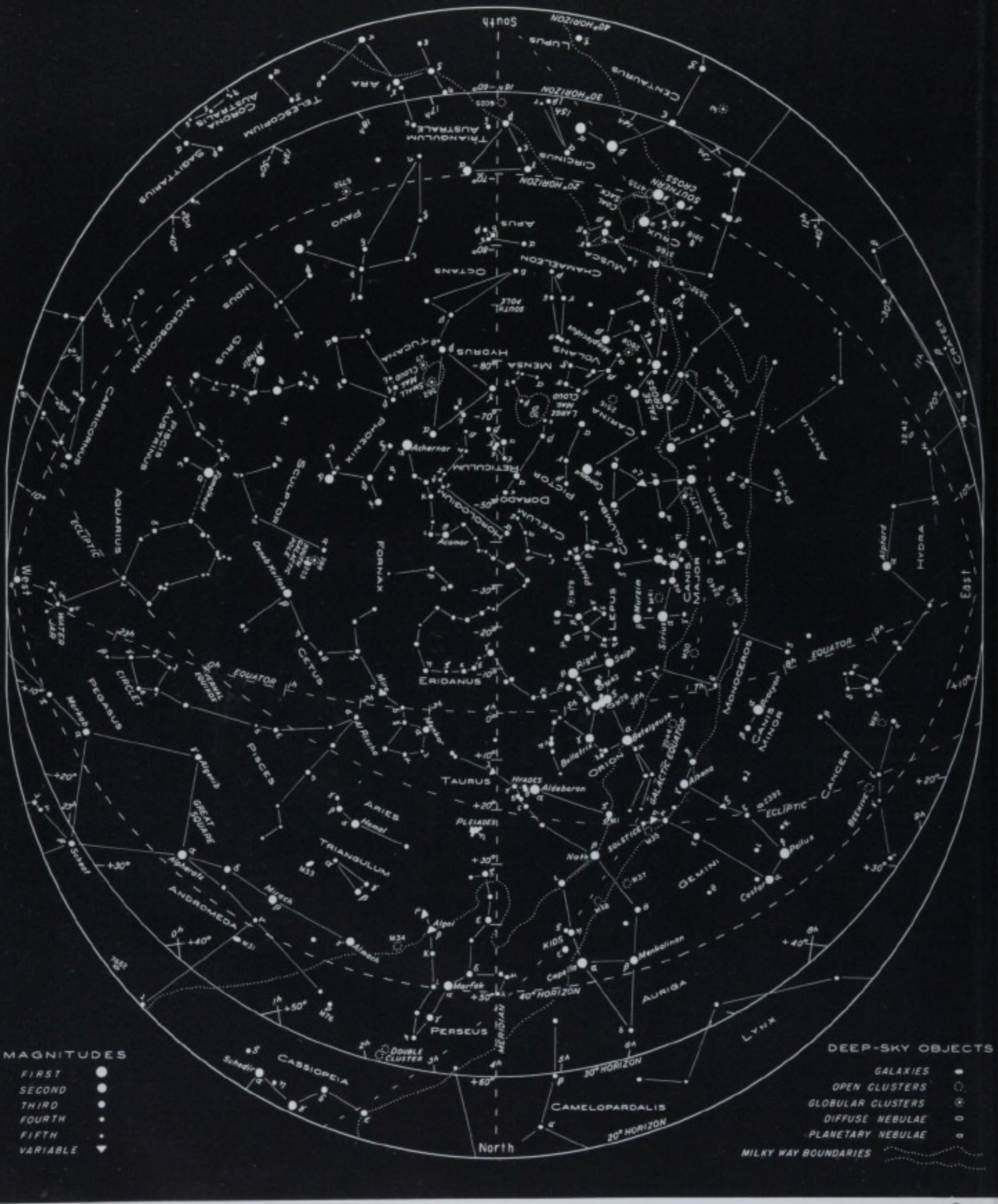
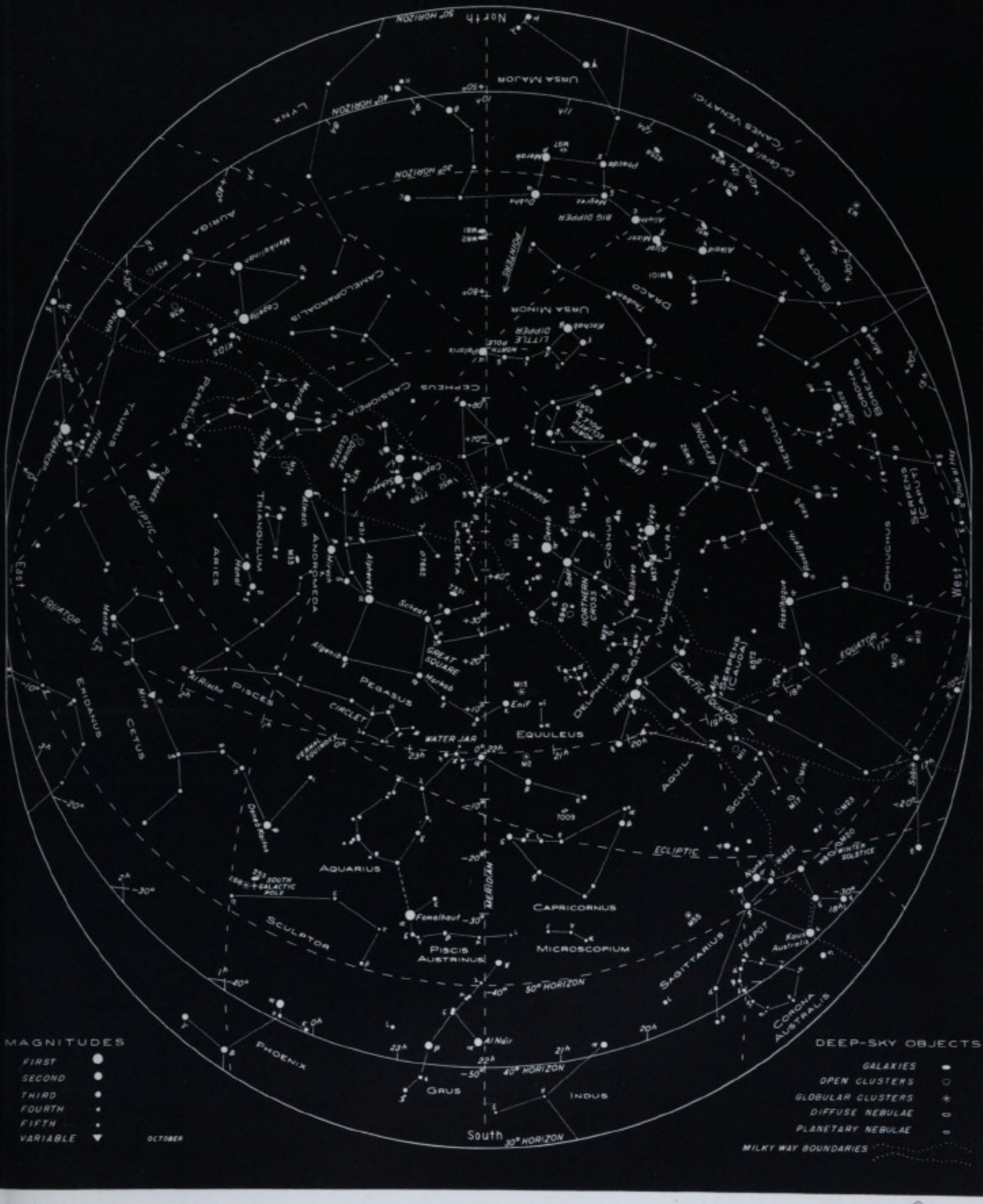


SOUTHERN STARS

The sky as seen from latitudes 20° to 40° south, at 11 p.m. and 10 p.m., local time, on the 6th and 21st of December; also, at 9 p.m. and 8 p.m. on January 6th and 21st. For other dates, add or subtract ½ hour per week. When facing south, hold "South" at the bottom; turn the chart to observe in other directions.

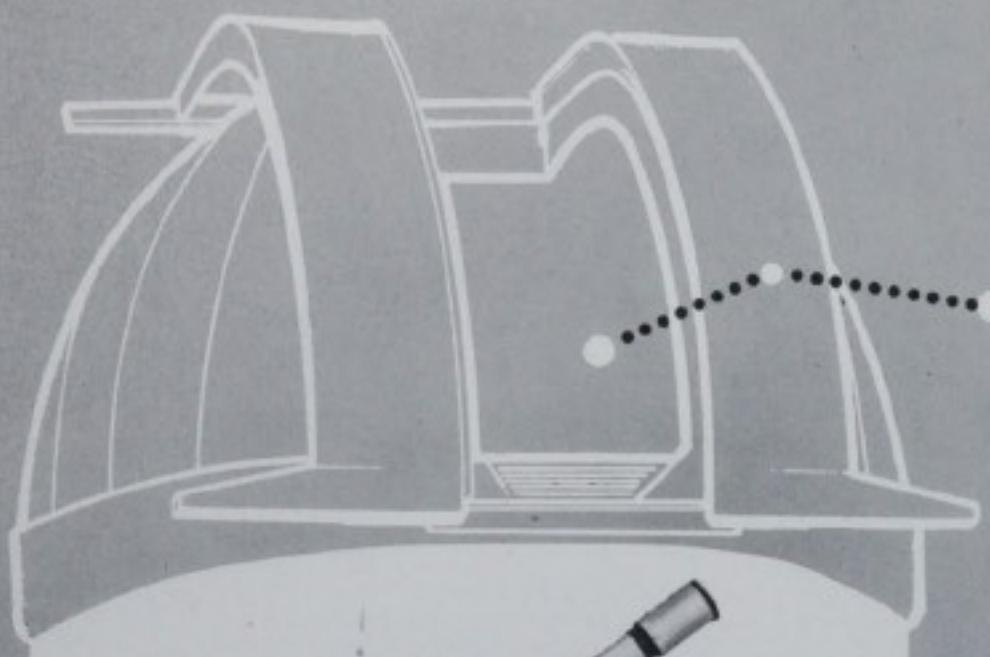
Near the Magellanic Clouds is a group of constellations named after man-made devices. These are Pictor the Painter's Easel, Reticulum the Net, Caelum the Graving Tool, and Horologium the Clock.



STARS FOR OCTOBER

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 6th and 22nd of October, respectively; also, at 7 p.m. and 6 p.m. on November 6th and 21st. For other dates, add or subtract ½ hour per week.

The bright band of the Milky Way, now almost directly overhead, marks the galactic equator, pinpointed by 1st-magnitude Deneb. Following Fomalhaut along the southern horizon is the faint constellation Sculptor, while Aquarius the Water Carrier is to the north of it.



ASTRO-DOME MAKES HISTORY!*

PATENTS PENDING

GOTO 8-INCH (20-CM.) EQUATORIAL

This fine observatory-type instrument has extreme versatility for all types of observing, and comes equipped with a star spectroscope and two cases full of accessories. It has an equatorial mounting, with large right-ascension and declination circles, and slow-motion controls.

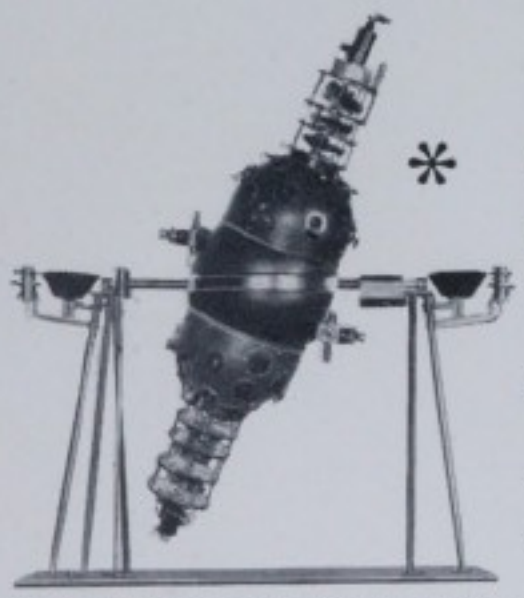
ACHROMATIC OBJECTIVE: Clear aperture 200 millimeters, focal length 3,000 mm., giving a focal ratio of f/15. Its theoretical resolving power on double stars is 0.58 second of arc, and it can detect stars of visual magnitude 13.3 in a perfectly transparent sky.

ELECTRIC CLOCK DRIVE: A magnetic speed adjuster gives complete control in right ascension.

GUIDE TELESCOPE AND FINDER: 80-mm. and 50-mm. apertures, respectively, giving powers of 30x and 7x.

EYEPIECES AND ACCESSORIES: Eight oculars, Herschel solar prism and solar projecting screen, star or zenith diagonal for viewing overhead objects, iris diaphragm to reduce objective aperture, three sun filters, three moon filters, and star spectroscope.

FINISH: The entire telescope and assembled parts and pier are handsomely finished in white and light gray, to blend with any modern observatory interior.



GOTO M-1 PLANETARIUM PROJECTOR

FEATURES:

1 Each individual projection unit has its own optical lens system, so very sharp star images are produced on the planetarium dome.

2 The entire celestial sphere is reproduced, and may be viewed as if the audience were anywhere in the world, including polar regions.

3 The apparent motions of the moon, sun, and five bright planets are reproduced at accelerated speeds.

4 The celestial equator and ecliptic can be projected as great circles on the sky.

5 As with the largest planetarium projectors, all three essential motions of the projector as a unit are provided with motor control, so that . . .

- A Daily motion around the polar axis reproduces the apparent diurnal movement of the sky and causes the heavenly bodies to rise and set.
- B Latitude may be changed and a trip around the world demonstrated by turning the projector on its horizontal supports (east-west axis).
- C The Great Year of 25,800 ordinary years can be simulated, as the projector is turned around the axis of the ecliptic poles, reproducing the gyration of the poles known as precession. The changing right ascensions and declinations of the stars are thus demonstrated.

6 All necessary auxiliary projectors and controls are provided at the remote-control console, including a pointer, switches for the stars and other objects, motor switches, and the like.

ASTRO-DOME, INC., for many years makers of fine domes for observatories and scientific institutions, has now become associated with Japan's Goto Optical Manufacturing Co., well-known for their optical products of the highest quality.

Astro-Dome is now United States representative for Goto planetarium projectors and telescopes. Thus, it is now possible for astronomers and educators everywhere to use the facilities of one firm to plan a complete installation for school, college, or community education in astronomy, from observatory building and instrument through a planetarium with interior and exterior domes and associated facilities.

Astronomers at universities and colleges, school teachers, planners of civic centers and museums, all are invited to take advantage, without obligation, of our services in the preliminary planning of astronomical facilities. We can supply, without charge, sets of blueprints showing typical installations; these can be used by your architect in planning astronomical structures.

We have technicians ready to install and service planetariums and telescopes, as well as Astro-Domes and Astro-Domettes. We are also maintaining an inventory of projectors and parts for Goto equipment.

Astro-Dome, with its years of experience in dome manufacture, has had no problem in designing for planetariums interior projection screens of either fiberglass or perforated aluminum, and these are available in various diameters. We supply, of course, exterior Astro-Domes to house telescope or planetarium, as well as complete observatory and planetarium buildings.

Recognizing our unique position in astronomical circles, we pledge service and quality to the Astro-Sciences.

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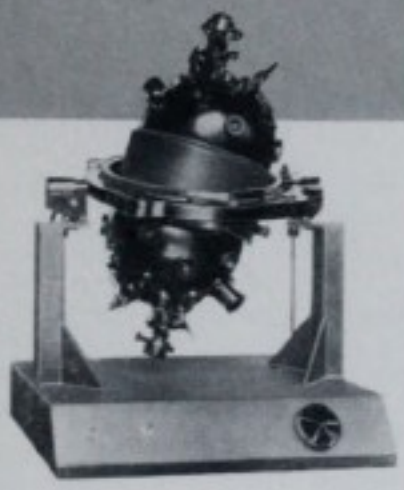

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GOTO S1 and S2 PLANETARIUM PROJECTORS

Designed and priced for modest installations, in domes 16 to 30 feet in diameter.

1 **Optical Projection.** Like their big relatives, the Goto Medium-Size and the Goto Large projectors, S1 and S2 have optical lens projection systems throughout, producing sharp star and planet images on modest-sized domes.

2 All three essential motions of the projector are obtained with motor drives. Therefore, the daily motion (rising and setting) of the stars may be reproduced: the great change of precession of the equinoxes (a 25,800-year cycle); and change of latitude, permitting imaginary voyages **completely** around the world in either direction.

3 The celestial equator, ecliptic, and Milky Way are projected.

4 The supporting stand is heavy and rigid, and designed with a horizontal east-west axis, as it is in all large planetariums.

5 Setting rings for the diurnal and precessional motions.

6 Individual projectors for the planets, sun, and moon.

GOTO 6-INCH (15-CM.) EQUATORIAL

*

A large refractor with the finest features, ready for immediate installation on its heavy metal pier. Equipped with setting circles and slow-motion controls—a versatile clock-driven equatorial.

OPTICS: The achromatic objective has a clear aperture of 150 millimeters, f/15, focal length 2,250 mm. It resolves double stars to about ¾ second of arc and detects stars fainter than magnitude 12½. Seven eyepieces are provided, as well as a finder telescope, of 50-mm. aperture and 12x magnification.

ACCESSORIES: Star diagonal, Herschel prism, two sun filters, a moon filter, star spectroscope, and accessories case.

FINISH: Instrument finished in white and light gray.

THE ALL-NEW ASTRO-DOMETTE

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Astro-Domettes have been developed for high schools and junior colleges. These units are fabricated on an assembly line basis, resulting in high quality yet modest cost. Because sections are stamped or molded, dome components are uniform and interchangeable. Astro-Domettes are available in sizes of 8, 10 and 12 feet outside diameters. In the space age, progressive schools will want to include this new aid to education in their science departments. Domettes are available in pastel colors.

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ASTRO-DOME
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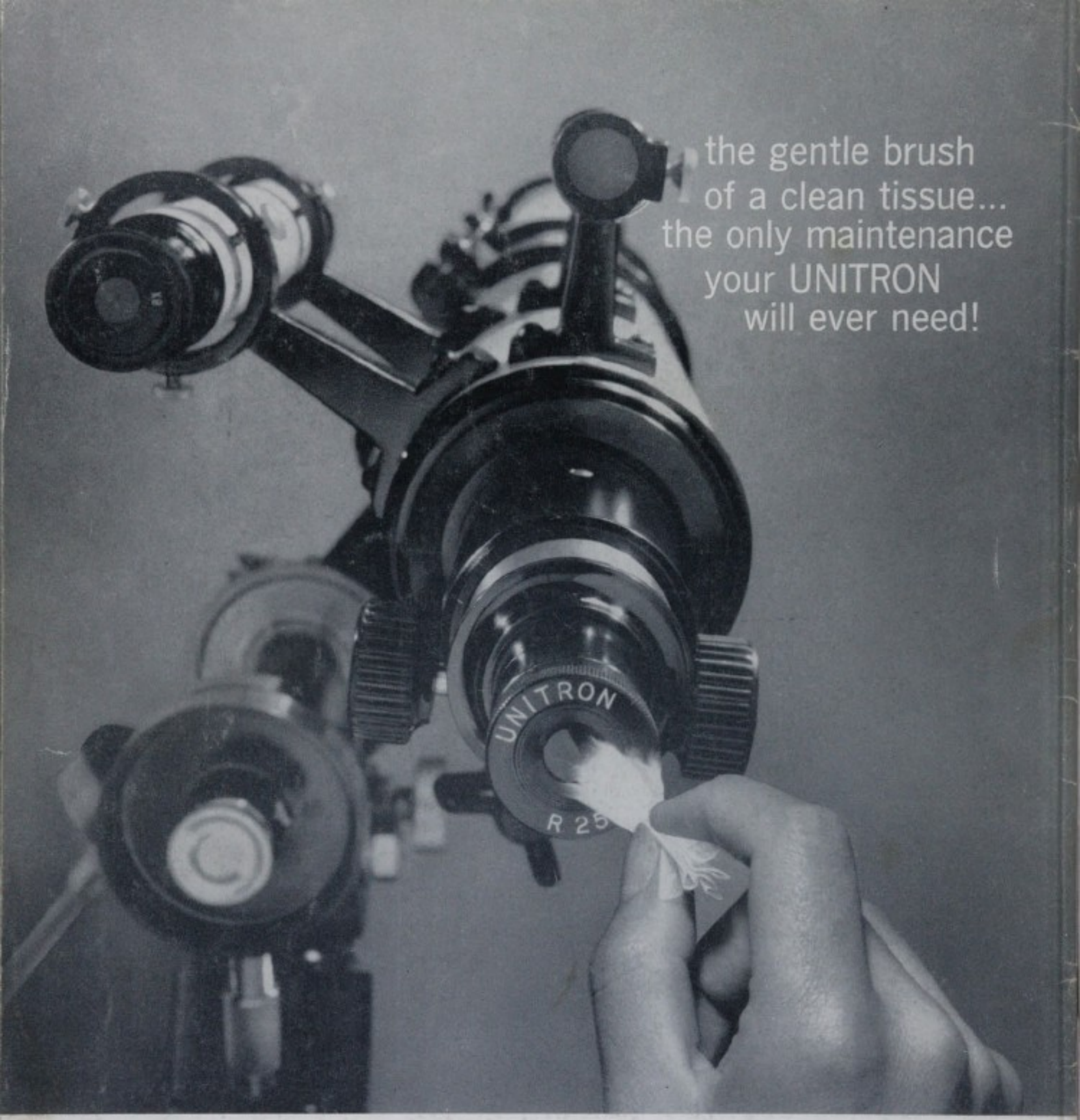

It's comforting to know that the UNITRON refractor you buy is built so well that the only maintenance it will ever require is an occasional brush of the eyepiece with a clean tissue.

Reflect a moment: can you say that about any type of telescope other than a good refractor?

Consider: a UNITRON has no optical elements to adjust . . . ever.

A UNITRON has no mirrors to become oxidized or be jarred out of alignment by vibration.

A UNITRON has a closed tube. There are no troublesome air currents to cause unsteadiness, poor definition, limited magnification . . . there's no prospect of trouble with internal dewing caused by dampness, with the resulting loss of definition and light.

There's no telescope so maintenance-free as a refractor. And there's no refractor so maintenance-free as a UNITRON.

All your UNITRON will ever ask of you is to be treated with the reasonable care and respect any fine instrument deserves. In return, it will give you a lifetime of dependable, trouble-free service.

MODEL 142 — COMPLETE with Equatorial Mounting and slow motion controls for both declination and R.A., setting circles and verniers, tripod, 8X-30 mm. viewfinder, standard rack and pinion focusing mechanism, 5 eyepieces, choice of UNIHEX or star diagonal and erecting prism system, sun projecting screen apparatus, sunglass, pocket eyepiece case, dewcap, dustcap, tripod shelf, wooden cabinets, instructions. **$435.**

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SEE PAGES 230 AND 231 FOR MORE ABOUT UNITRON.